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FORAMINIFERA FROM THE TYPE SECTION OF THE SAN LORENZO FORMATION SANTA CRUZ COUNTY CALIFORNIA

BY

FRANK R. SULLIVAN

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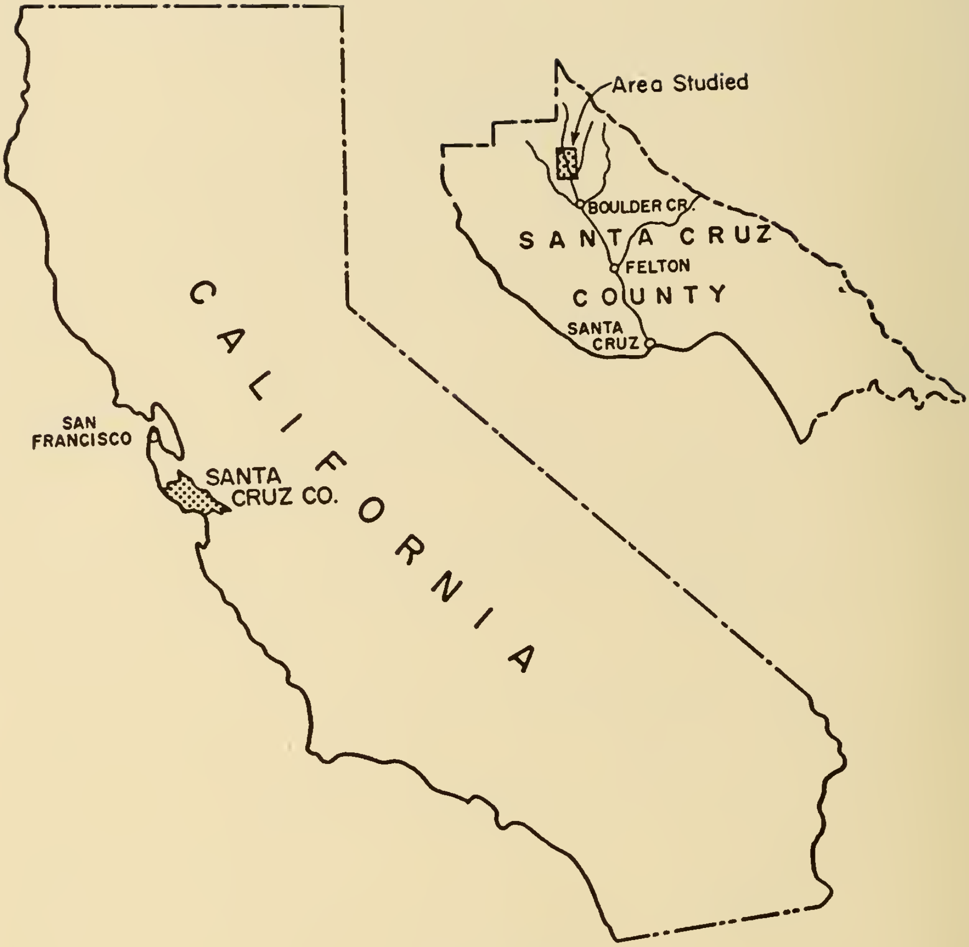


Fig. 1. Index map.

FORAMINIFERA FROM THE TYPE SECTION OF THE SAN LORENZO FORMATION SANTA CRUZ COUNTY, CALIFORNIA

BY

FRANK R. SULLIVAN

(A contribution from the University of California Museum of Paleontology)

ABSTRACT

Two hundred thirteen species and varieties of fossil Foraminifera of late Eocene, Oligocene, and "Oligo-Miocene" age are recorded from the upper Butano, San Lorenzo, and lower Vaqueros formations of the Santa Cruz Mountains, California. This stratigraphic sequence is exposed along the San Lorenzo River, in the type area of the San Lorenzo formation, two to four miles north of Boulder Creek, in Santa Cruz County. *Haplophragmoides deflata, Lagena becki, Plectofrondicularia minuta,* and *Valvulineria tumeyensis* var. *conica* are described as new. The foraminifers indicate that this sequence was deposited during Narizian, Refugian, and early Zemorrian time, in marine waters mostly at bathyal depths, with tropical to subtropical surface temperatures throughout. The indications are that normal open-sea conditions prevailed, except toward the middle of the sequence, until late within this interval of time.

INTRODUCTION

The Santa Cruz Mountains

The Santa Cruz Mountains rise along the California coast between the cities of San Francisco and Santa Cruz. Their main ridges follow the general northwest-southeast trend of the Coast Ranges of California, of which they are a part. They slope steeply to the northeast, where they are bordered by the San Andreas fault; to the southwest, where many streams descend directly to the Pacific Ocean, the slope of the range is much more gradual.

Unlike the ranges farther south and inland, the Santa Cruz Mountains are covered by rich vegetation supported by the humidity of the region, and outcrops are limited. However, the southwest-flowing streams have cut deeply into the terrain, revealing a sequence of Tertiary beds that are greatly folded and faulted, with major structural axes that roughly parallel the main watershed and the San Andreas fault. The largest of such streams is the San Lorenzo River, along which an unbroken sequence of strata is exposed from four to two miles north of the town of Boulder Creek. This sequence extends from beds high in the uppermost sandstones of the Butano formation below, as exposed in the axis of the Butano anticline, southward and stratigraphically upward, allowing for one minor local fold, through 2,250 feet of finer-grained clastics that constitute the overlying type San Lorenzo formation, into the lower sandstone beds of the Vaqueros formation (figs. 1, 2).

Fossil foraminifers were collected from fifty localities evenly distributed throughout this sequence (fig. 3). A traverse was plotted along the river (fig. 3), and a local stratigraphic column (fig. 4) was measured by Brunton compass and steel tape.

ACKNOWLEDGMENTS

I am sincerely grateful for the supervision and help given by R. M. Kleinpell, who originally suggested the project; and for the assistance furnished, through him, by Lesh Forrest, R. Stanley Beck, and the several other petroleum geologists who from time to time have been able to supply either surface or subsurface information of significance, and likewise by the late Professor H. G. Schenck of Stanford University. I am grateful to J. W. Durham and C. M. Gilbert for their criticism of the manuscript; to Paul Wesendunk for his prolonged assistance in the field; to R. C. Blaisdell, who helped measure the section; and to Earl E. Brabb, of Stanford University, for his aid and coöperation in the field. Mrs. Margaret Hanna prepared the figures of the Foraminifera, and O. J. Poe the text figures. Finally, I am indebted to my wife for her assistance in preparing the manuscript.

GENERAL GEOLOGY AND PREVIOUS WORK IN THE AREA

The geology of the Santa Cruz Quadrangle was first comprehensively studied and mapped by Branner, Newsom, and Arnold (1909). Above the basement complex of granitic rocks, schists, and limestones, all of unknown age, they recognized fourteen Mesozoic and Cenozoic formations. For the nature and areal distribution of these formations, and for the structure of the Santa Cruz range in general, see the Santa Cruz Folio prepared for the United States Geological Survey by Branner, Newsom, and Arnold (1909).

The Santa Cruz Mountains are made up mostly of marine sandstones and shales of Tertiary age, which rest with depositional contact on sediments and crystalline rocks of Cretaceous or older age. Megofossils, especially marine mollusks, occur more or less throughout the local sequence of Tertiary formations, but are notably scarce in the lower and middle Tertiary. This scarcity of larger fossils has in the past prevented an accurate and detailed determination of the stratigraphic and structural history of the Santa Cruz Mountains. In recent years it has been found, however, that fossil foraminifers are locally abundant in this part of the column. Petroleum exploration in the area has during the last fifteen years greatly stimulated the search for these microfossils, the study of which has served to clarify many aspects of the early and middle Tertiary history of the range.

Pre-Tertiary as well as Tertiary Foraminifera have been found in the Santa Cruz Mountains. A middle Cretaceous age has been suggested for a foraminifer faunule from part of the Franciscan formation (Calera limstone) by Church (1952, p. 70). The oldest beds assigned to the Tertiary System in the area by Branner, Newsom, and Arnold appear as limestone inclusions in the diabase exposed just north of Butano Ridge, and contain megafossils which are believed to be of lower Eocene age. Lower Eocene Foraminifera have been recorded from the Woodside area, southeast of Half Moon Bay, by Graham and Classen (1955), and more recently Paleocene Foraminifera have been reported from a mudstone underlying the Butano formation on the north flank of Ben Lomond Mountain by Brabb (1959, p. 9). The genus *Miogypsina* has been found by Hacker in an isolated outcrop of indeterminate stratigraphic position but apparently within the limits of the San Lorenzo formation *sensu lato,* and has been described by Graham and Drooger

(1952). Foraminifer assemblages have been previously recorded from the Butano, San Lorenzo, and Vaqueros formations (Valentine, 1928; Hobson, 1932; Cushman and Hobson, 1935; Schenck, 1936; Schenck and Kleinpell, 1936; Forrest, 1937; Kleinpell, 1938; Forrest, 1943). Smaller foraminifers abound not only in the finer-grained clastic sediments of these three formations but also in the overlying Sandholt and Monterey formations (Kleinpell, 1938; Wesendunk, 1956; Fairchild, 1957; Brabb, 1959; Christensen, 1960) and in the Pliocene and Pleistocene Purisima and Merced formations (Stewart and Stewart, 1933; Goodwin and Thomson, 1954; Bandy, 1955).

All these late Mesozoic and Cenozoic strata of the Santa Cruz Mountains have been strongly deformed. Folding and faulting have occurred many times during the Cenozoic history of the area, and the present geologic structure of the region is very complex. Although minor structural details are obscured by a thick covering of soil and vegetation, the major structural features are fairly evident (Branner, Newsom, and Arnold, 1909, p. 9, map and structure sections). The most intense movements, perhaps as much horizontal as vertical, have been along the northwest-southeast trend of the San Andreas fault, but are less pronounced toward the northeast and southwest. Much deformation has taken place also in the region between Castle Rock Ridge and Ben Lomond Mountain, where the Miocene and older beds that crop out in narrow bands parallel to the San Andreas fault have been crumpled into sharp, locally faulted folds, and in many places, mainly toward the west and southwest, there has been intense minor folding and strong overturning in the finer-grained beds.

The present study is limited to that part of the local stratigraphic column which is either high in the lower Tertiary or low in the middle Tertiary: principally the San Lorenzo formation, but also the underlying upper Butano and overlying lower Vaqueros formations. A relatively undisturbed and continuously fossiliferous sequence through this part of the column is exposed along the bed of the San Lorenzo River north of the town of Boulder Creek. Long before attention was focused upon its rich fossil foraminifer faunas, this sequence was selected to serve as the standard of reference, or type section, for the locally distinctive formation to be known as the San Lorenzo.

STRATIGRAPHY

The Stratigraphic Sequence North of the Town of Boulder Creek

Formational terminology.—The San Lorenzo formation was so named by Ralph Arnold (1906, p. 16). He designated its type locality as "on San Lorenzo River, 2½ miles above the town of Boulder Creek, Santa Cruz County, California," and defined the formation as follows:

> The San Lorenzo formation consists essentially of a series of grayish "muddy" shales and fine sandstones, which are typically exposed along the bed of the San Lorenzo River, about 2 miles above Boulder Creek, Santa Cruz County. The formation extends westward from the type locality into the Big Basin, on the north side of which it rests conformably against the older yellowish sandstones (possibly Oligocene in Age) of the Butano Ridge. To the southeast of the exposures on San Lorenzo River the formation, in the shape of a broad anticlinal nose, gradually dips conformably under the sandstones and conglomerates of the lower Miocene. The approximate thickness of the formation in the vicinity of the type locality is about 2,300 feet.

Arnold (p. 18) noted also that the Vaqueros formation, named in 1904 by Hamlin at its type locality in the foothills west of the Salinas Valley, rested conformably upon the San Lorenzo shales in the general region of the Santa Cruz Mountains.

Two years later, Arnold (1908, p. 348), discussing the Tertiary sequence of the Santa Cruz Mountains, recognized the sandstones of Butano Ridge, conformably underlying the San Lorenzo shales, as a formational unit at least 2,100 feet thick, and referred to the unit as "Probable lower Oligocene sandstone." In discussing the strata overlying the San Lorenzo formation, Arnold (p. 349) referred to fine massive sandstones on Twobar Creek (a stream just east of, and emptying into, the San Lorenzo River) as transitional between the San Lorenzo and Vaqueros formations. He pointed out that, although the Vaqueros lies conformably above the San Lorenzo formation in the general region, gradational changes make the contact difficult to define in many places.

The treatment of the San Lorenzo formation by Branner, Newsom, and Arnold (1909, p. 3) was essentially the same as that in Arnold's previous work. However, in the geological descriptions and mapping of the Santa Cruz Quadrangle as presented in this early folio, the formation underlying the San Lorenzo shale was for the first time referred to as the Butano sandstone, and was described as those "outcrops in a triangular area, the eastern point of which is at San Lorenzo River, 4 miles north of the town of Boulder Creek." The sandstones overlying the San Lorenzo formation were again recognized (*ibid.*, p. 4) as belonging to the Vaqueros, except for the transitional sandstones on Twobar Creek, which were mapped with the San Lorenzo on the basis of faunal affinities.

Subsequently, different thicknesses have been reported for the San Lorenzo formation, most of them (though not all) greater than the original estimate, and both the lower and upper contacts have been more closely observed and sometimes disputed.

Schenck (1936, p. 69) stated that "the San Lorenzo formation lies with probable disconformity, but without marked angular unconformity, above the Butano sandstone" in the Kings Creek area, and recorded a measured thickness of 2,700 feet for the San Lorenzo formation along the San Lorenzo River in contrast to Arnold's original estimate of "about 2,300 feet." Schenck further stated (p. 72) that on the San Lorenzo River the Vaqueros lies with questionable disconformity above the San Lorenzo formation.

A year later, in an abstract discussing the type San Lorenzo formation, Forrest (1937, p. 326) also suggested that "there may be a hiatus between the Butano and the superjacent San Lorenzo, even though the beds are structurally accordant," and in 1943 (p. 199) he recorded a thickness of almost 3,000 feet for the San Lorenzo formation along Bear Creek and Kings Creek.

Thus, although subsequent measurements differ somewhat from the original estimate of thickness for the typical San Lorenzo formation, and the original age designations have been altered somewhat by later workers (as will be discussed below), little change has taken place in the understanding of stratigraphic relationships in the type San Lorenzo area.

Butano formation.—The type Butano formation is exposed on the two flanks of a southeastward-plunging anticlinal ridge about ten miles long, the easternmost extension of which is on the San Lorenzo River, where both structure and formation plunge conformably beneath the San Lorenzo shale (figs. 2, 3). The base of the typical formation is not exposed. The Butano is known to be at least 2,100 feet thick toward the west, where it crops out between the crest of Butano Ridge and Pescadero Creek. However, only 160 feet of south-dipping beds are exposed between the surface expression of this anticline and the contact with the overlying San Lorenzo formation on the San Lorenzo River. The Butano is here composed of brown and buff-colored, medium- to coarse-grained massive arkosic sandstone, interbedded toward the top with gray to black, medium- to fine-grained siltstone stringers. Except for these few finer-grained beds the Butano sandstone is unfossiliferous.

San Lorenzo formation.—Resting conformably on the Butano sandstone, and measuring 2,250 feet in thickness at the type area (figs. 2, 3), the strata of the San Lorenzo formation dip toward the south except near the middle of this area of outcrop, where the attitudes are reversed and a minor interval of this sequence is repeated by a local fold. Typically the San Lorenzo is composed of gray, fine- to coarse-grained siltstone with occasional hard, limy beds, and some brownish, fine- to medium-grained sandstone layers. The siltstone is mostly fine-grained and very well-bedded through the lower third of the formation, where it is interbedded with carbonaceous shales toward the base and includes a few massive sandstone beds, one 15 feet thick but most of them less than 2 feet thick, toward the top. Above this, the siltstones become medium-grained and massive, and contain occasional hard, limy lenses up to 2 feet thick. This massive siltstone, characteristic of the upper two-thirds of the formation, becomes progressively coarser-grained toward the top of the formation, where it is conformably and gradationally overlain by the Vaqueros sandstone (figs. 2, 3).

Earl E. Brabb, of Stanford University, has mapped two members of the San Lorenzo formation throughout the Big Basin area. With reference to the samples herein reported upon (see fig. 5) Brabb writes (personal communication): "The contact between the upper and lower member in the San Lorenzo River section is . . . between B-2250 and B-2251 where there is an abrupt change from laminated shale to massive sandstone. The contact is marked by a glauconitic siltstone." Brabb thinks that the type section of the San Lorenzo formation is approximately 1,800 feet thick, "but the minor faults, flexures, and poor attitudes make precise measurement impossible" (verbal communication).

Vaqueros formation.—In the area north of Boulder Creek, from 2,200 to 2,400 feet of Vaqueros formation are exposed above the type San Lorenzo. The Vaqueros is composed chiefly of brown or buff-colored, medium- to coarse-grained massive arkosic sandstones, but locally the rock type varies from mudstone through interbedded dark gray siltstone and sandstone to conglomerate. Alternating thick beds of varying grain-size and texture appear to be more characteristic of the Vaqueros in this region than are the more uniform massive beds found widely and characteristically through the upper two-thirds of the finer-grained and essentially silty San Lorenzo. Some lateral gradation between the two types of bedding occurs within both the San Lorenzo and the Vaqueros formations. Precise mapping of their contact is therefore difficult.

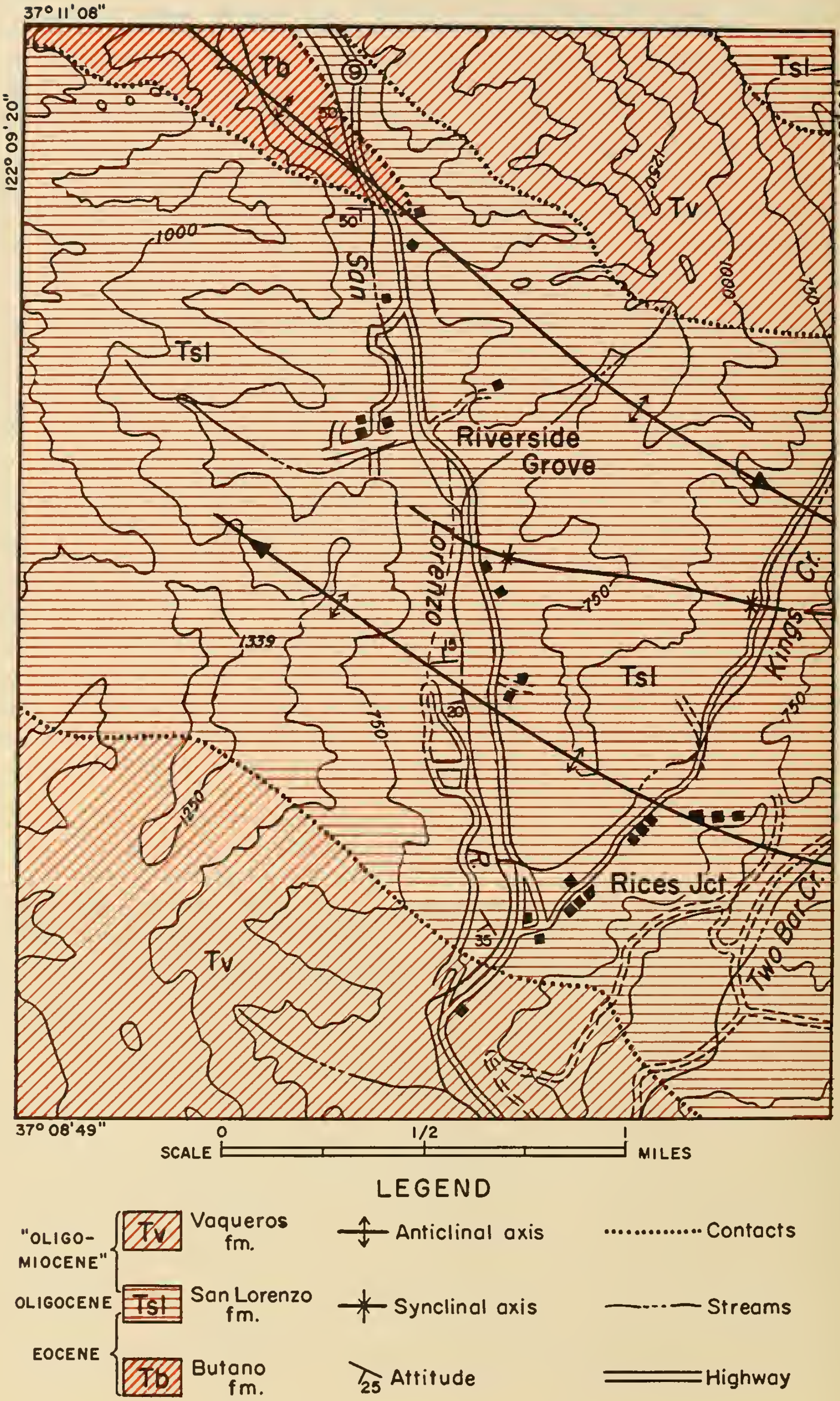


Fig. 2. Geologic map of the Type Locality of the San Lorenzo formation. (Based on enlargement of a portion of Ben Lomond Quadrangle, Army Map Service, 1946 ed.)

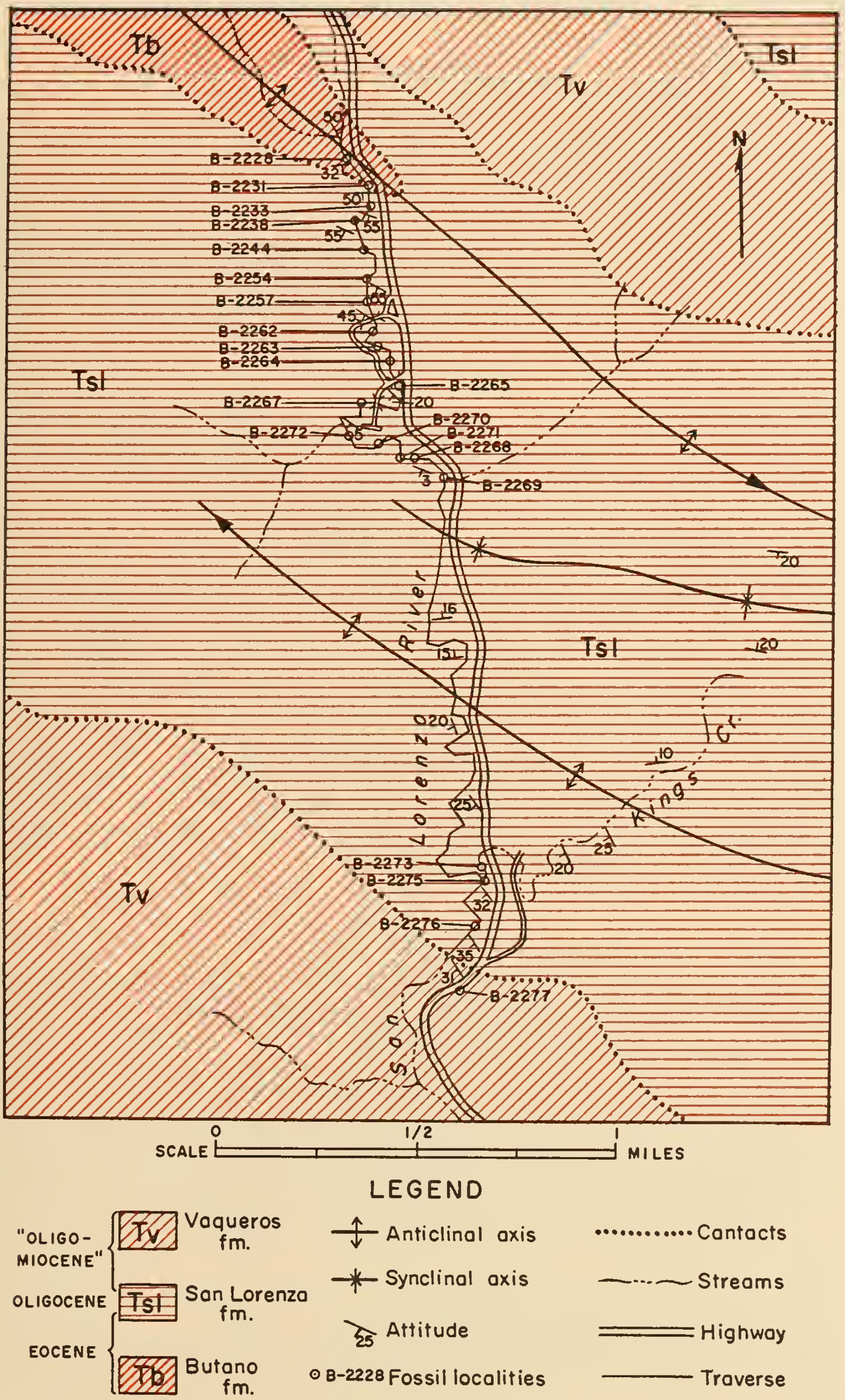


Fig. 3. Fossil localities along the Type Section of the San Lorenzo formation. (Based on tracing from U. S. Forest Service aerial photograph contact prints CDF5-2-40 and 41.)

PALEONTOLOGY

THE FORAMINIFERA

Although larger fossils are scarce in the type San Lorenzo, fossil foraminifer assemblages were collected from fifty localities rather evenly distributed through the uppermost Butano, San Lorenzo, and lowermost Vaqueros formations. Two hundred thirteen species and varieties of Foraminifera were identified, representing seventy-eight genera and twenty-six families. Although calcareous perforate forms make up the majority of this total—calcareous imperforate forms being represented by only four species of two genera—arenaceous Foraminifera are numerous and diverse, comprising eleven families, nineteen genera, and thirty-five species.

Species of *Haplophragmoides, Cyclammina, Discammina, Eggerella,* and *Trochammina* are the most abundant arenaceous forms. Of the calcareous perforate groups, the family Lagenidae is the most abundant and diverse, with eleven genera and sixty-two species, twenty-one of which represent the genus *Robulus. Dentalina,* with thirteen species, and *Nodosaria* and *Lagena,* with six species each, are also well represented. The Buliminidae constitute the next most diverse group, with thirty-two species belonging to twelve genera of which *Bulimina, Bolivina,* and *Uvigerina* appear in greatest numbers. The family Heterohelicidae is also well represented, with five genera and twenty-four species, thirteen of which belong to *Plectofrondicularia* and five to *Nodogenerina.* Fourteen species and five genera represent the Rotaliidae, with *Eponides, Gyroidina,* and *Valvulineria* the most diverse and abundant. The Anomalinidae, with five genera and nine species, include especially abundant *Cibicides* and *Anomalina.* Of the remaining eight families present, the Ellipsoidinidae, represented by seven species of *Ellipsonodosaria,* the Cassidulinidae with three genera and a preponderance of *Cassidulina,* and the Globigerinidae, occur in the greatest numbers.

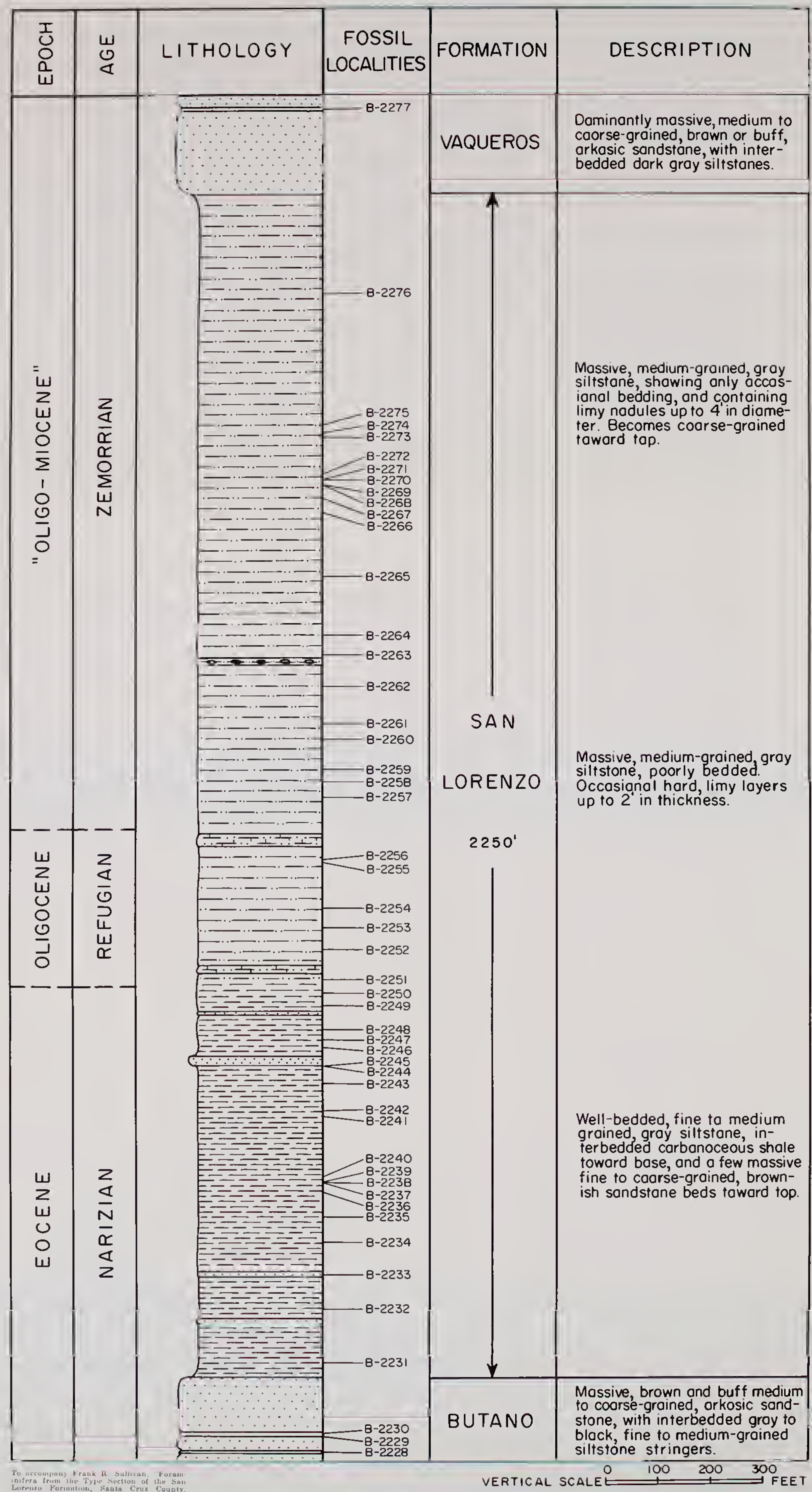
BIOSTRATIGRAPHY

The foraminiferal assemblages found in the stratal sequence exposed upstream from Boulder Creek, California, are very diverse. Some eighteen distinct faunules[1] may be recognized among the fifty assemblages collected from this section (figs. 3, 4) along the San Lorenzo River. Of these, seven characterize local stratigraphic intervals of some thickness; hence the stratal intervals so characterized may be described as zonules.[2] In view of the high degree of lithologic uniformity of the stratal sequence in which they occur, these zonules, and also the individual faunules, have each been given a distinct designation here, for purposes of biostratigraphic reference. Their specific composition, both qualitative and quantitative, is depicted in figure 5.

---

[1] C. L. and M. A. Fenton (1928, pp. 20–22) defined a faunule as "... an assemblage of fossil animals, associated in one or a few contiguous strata, and dominated by the representatives of one community, either an association or layer society."

[2] The term "Zonule," introduced by the Fentons (1928), was defined as "... the strata or stratum which contains a faunule, its thickness and area limited by the vertical and horizontal range of the faunule."



Dominantly massive, medium to coarse-grained, brown or buff, arkosic sandstone, with interbedded dark gray siltstones.

Massive, medium-grained, gray siltstone, showing only occasional bedding, and containing limy nodules up to 4' in diameter. Becomes coarse-grained toward top.

Massive, medium-grained, gray siltstone, poorly bedded. Occasional hard, limy layers up to 2' in thickness.

Well-bedded, fine to medium grained, gray siltstone, interbedded carbonaceous shale toward base, and a few massive fine to coarse-grained, brownish sandstone beds toward top.

Massive, brown and buff medium to coarse-grained, arkosic sandstone, with interbedded gray to black, fine to medium-grained siltstone stringers.

To accompany Frank R. Sullivan, "Foraminifera from the Type Section of the San Lorenzo Formation, Santa Cruz County, California," Univ. Calif. Publ. Geol. Sci., Vol. 37, No. 4

Fig. 4. Stratigraphic column of the San Lorenzo formation at the type locality.

ECOLOGY

General

Throughout the section studied, marine deposition within the so-called medium depths (naritic to bathyal) is indicated by the abundance of the Lagenidae, Anomalinidae, and Heterohelicidae. The absence of brackish-water and littoral forms is in keeping with this interpretation of the depths at which the local upper Butano, San Lorenzo, and lower Vaqueros formations were deposited here. Within the limits of these medium depths, a bathyal origin is indicated for most of the strata in the section; but during deposition of part of the lower San Lorenzo a temporary shallowing took place, followed by a return to bathyal depths in the middle of the section. These bathymetric fluctuations may be reviewed in greater detail by a discussion of the formations and the individual biostratigraphic units in sequence from oldest to youngest.

Upper Butano Faunules

Amphimorphina Faunule.—The bathyal district is suggested as the depositional environment of the sediments containing this faunule, which occurs 145 feet below the top of the Butano formation, and stratigraphically is the lowest faunule in the sequence studied. Furthermore, a depth no greater than bathyal is indicated by the abundance and diversity of Lagenidae, characteristic of the continental shelf and slope between 50 and 500 fathoms (Cushman, 1948, p. 44). Further support for this interpretation of maximum depth is offered by the abundance of *Ellipsonodosaria* and *Nodogenerina,* which exhibit convergence with the uniserial lagenids and are also commonest at medium depths; and by *Cibicides cushmani.* The latter is similar in form to *Cibicides lobatula* (Walker and Jacob), which has been collected by the Albatross Philippine Expedition from medium depths (Cushman, 1921, p. 313) and is further reported from neritic depths by Natland (1933, chart) and by Bandy (1953).

By the same token, a depth not shallower than bathyal is suggested by the abundance of several other conspicuous forms: *Plectofrondicularia* is morphologically similar to *Frondicularia,* which has been reported from the warmer waters of both the Atlantic and the Pacific at bathyal depths (Cushman, 1923*b,* pp. 141–143); *Uvigerina garzaensis* resembles *U. asperula,* which has been reported from many stations of the North Pacific in cold water of bathyal and abyssal depths (Cushman, 1913, p. 101); *Bulimina ovata* has been reported as common in cold water at bathyal and abyssal depths along the eastern coast of the United States and in the Gulf of Mexico (Cushman, 1922, p. 100) and, although as rare, also from bathyal depths in the Pacific (Cushman, 1921, p. 164); *Eponides umbonatus* has been reported from Albatross and Challenger stations in the North Pacific at bathyal and abyssal depths (Cushman, 1915, p. 60); and *Chilostomelloides oviformis* is similar in form to *Chilostomella ovoidea,* which has been reported from both the Atlantic and the North Pacific in cold water of bathyal and abyssal depths (Cushman, 1924, p. 2; Cushman, 1921, p. 283). The two arenaceous genera herein represented are considered to have little bathymetric significance, although their presence is in keeping with the interpretation above. As seems to apply to arenaceous forms in general, their distribution here also appears to be "governed largely by the nature of the sea bottom" (Kleinpell, 1938).

The faunule is distinctive in that a great number of species are represented (about 75), and in that the majority of these species make their only local appearance at this horizon. The abundance of the planktonic genera *Sphaeroidina* and *Globigerina* indicates that the area was connected with the open sea at the time of deposition.

Valvulineria Faunule.—Some shallowing of the sea bottom in the area may account for the difference in the composition of this meager faunule, the flourishing of which seems to have succeeded that of the *Amphimorphina* Faunule in this locality. This is suggested by the abundance of *Cassidulina* cf. *C. diversa,* a form similar to *C. crassa,* which, though relatively eurybathic, is more often found in shallow waters than are other species of the genus; and by the increase in numbers of *Bolivina,* which, although it may "persist in considerable numbers to great depths," seems to be "most abundant above the edge of the continental shelf" (Kleinpell, 1938, p. 15). In contrast to these indications of shallowing, however, a decrease in temperature is suggested by a change in faunal aspect from the greater number of species and fewer individuals per species so apparent in the *Amphimorphina* Faunule to the fewer species and greater number of individuals per species that characterize this higher assemblage.

The presence of planktonic *Globigerinella* indicates continued access of the area to the open ocean during deposition of the uppermost Butano formation.

Lower San Lorenzo Faunules

Ellipsonodosaria and Eggerella Faunules.—Neritic depths, more shallow than those at which the *Amphimorphina* Faunule lived, and with continued open-sea conditions, are suggested for the lower of these two faunules stratigraphically lowermost in the San Lorenzo formation, because of the increase in number and dominance of *Nodosaria, Nodogenerina,* and *Ellipsonodosaria,* and the presence of *Globigerina.* In the higher (or *Eggerella*) faunule the abundance of arenaceous forms, to the exclusion of calcareous forms, is indicative of locally altered bottom conditions rather than of any definite change in depth.

Globigerina and Bulimina-Valvulineria Zonules.—Continued neritic depths are indicated for this interval of almost 500 feet in thickness in the lower San Lorenzo, by the abundance, throughout, of the very finely costate, almost smooth-walled *Bulimina microcostata,* a form analogous to living representatives of this stock which appear to exhibit a neritic optimum. Toward the top of this interval some deepening of the bottom is suggested by the increased numbers of *Plectofrondicularia* and of *Cassidulina globosa,* a form morphologically similar to *C. subglobosa* which has been cited as a deep-sea form of cassidulinid. The local dominance of arenaceous over calcareous forms at two horizons within the upper, or *Bulimina-Valvulineria* Zonule indicates an alternation of bottom conditions that is in keeping with the sequence of lithologies in this interval.

Continued open-sea conditions are indicated by the dominance of *Globigerinella, Sphaeroidina,* and *Globigerina* up through the *Globigerina* Zonule. And although connection to the open sea is indicated as continuing on through the lower half of the *Bulimina-Valvulineria* Zonule, the marked absence of planktonic forms in the upper half of this zonule suggests some decrease in access to open-ocean currents.

Middle and Upper San Lorenzo Faunules

Bulimina-Plectofrondicularia Faunule.—About 25 feet stratigraphically above the top of the *Bulimina-Valvulineria* Zonule a faunule appears which is almost entirely different from those in the lower member of the San Lorenzo formation. The species of *Valvulineria* (*V. tumeyensis*) that is so abundant throughout the subjacent zonule persists in abundance here, but a new group of buliminids appears, along with *Uvigerina, Robulus, Cibicides,* and a large *Plectofrondicularia.*

In this stratigraphically next highest faunule a return to bathyal depths is indicated by the replacement of the nearly smooth-walled *Bulimina microcostata* by the strongly costate *B. sculptilis,* a form resembling *B. buchiana* which is reported from South Atlantic Challenger and North Pacific Albatross stations at great (bathyal and abyssal) depths (Cushman, 1911, p. 85). This increase in depth is indicated also by the return in quantity of *Plectofrondicularia,* by the presence of a papilate variant (*nudorobusta*) of *Uvigerina garzaensis,* previously discussed, and by the appearance of the bulbous *Bulimina guayabalensis* var. *ampla,* a form similar to *B. affinis* which is reported from deep waters of the North Pacific by Cushman (1911, p. 73). A depth no greater than bathyal, however, is suggested by the appearance of *Cibicides hodgei,* a species similar to *C. cushmani,* discussed above, and an abundance of lagenids, especially the genus *Robulus.*

The absence of planktonic forms in this faunule suggests a continued restriction to the earlier open-sea connections.

Planulina-Plectofrondicularia Zonule, and Virgulina-Plectofrondicularia Faunule.—Continued bathyal depths are indicated for this succeeding interval by the persistence of *Plectofrondicularia,* by the appearance of *Cibicides pseudoungerianus* var. *evolutus,* a form similar to *Cibicides wuellerstorfi* (Schwager), which has been recorded from the Pacific at bathyal depths by Cushman (1921, p. 314), and by the first appearance in the column of costate uvigerinids—forms which have a deep-water optimum. Again a depth no greater than bathyal is indicated, however, by the persistence of forms such as *Cibicides hodgei* through the lower part of the interval and by the abundance of *Robulus* throughout.

Here again the absence of planktonic forms suggests a continuation of those paleogeographic conditions which began just before the change from lower to upper San Lorenzo deposition, and appear to have shut off the area from the open-sea connections of early San Lorenzo time.

Cassidulinoides Faunule, Cyclammina, Lower Cassidulina, Bolivina, and Uvigerinella Zonules, and Upper Cassidulina, Eponides, and Robulus Faunules.—The bathyal district is still indicated as the depth of deposition for this entire interval of strata because of the persistence of *Plectofrondicularia* and of *Cibicides pseudoungerianus* var. *evolutus,* and the temporary appearance of the living bathyal species *Buliminella subfusiformis.* That the sediments of this interval were probably not deposited in water deeper than bathyal is suggested by the increased number of lagenids and the reappearance of *Ellipsonodosaria.* A depth no shallower than bathyal is likewise suggested by the presence of several forms of the sort usually showing deep-water environmental optima. These include *Cassidulina crassipunctata, C. globosa,* and *Cassidulinoides californienses,* forms similar to *Cassidulina laevigata, C. subglobosa,* and *Cassidulinoides bradyi* (Norman), respectively, which are reported from the North Pacific in deep cold water by Cushman (1911, pp. 96–100); *Uvigerina obesa* var. *impolita,* a form similar to *U. pygmaea* which is reported from the cold deep waters of the Pacific (Cushman, 1913, p. 96); *Gyroidina orbicularis* var. *planata,* a form similar to *Gyroidina soldanii* reported from North Pacific Challenger and Albatross stations living at bathyal and abyssal depths (Cushman, 1915, p. 71); and *Anomalina californiensis,* a form similar to *Nonion umbilicatulum* (Montague) which is recorded from North Pacific Challenger and Albatross stations in waters of bathyal and abyssal depth (Cushman, 1914, p. 24). However, *Eponides kleinpelli,* a form similar to *"Truncatulina" haidingerii* which is recorded as most common from the Pacific at bathyal depths (Cushman, 1921, p. 315), might represent a more eurybathic form, ranging upward onto the continental shelf, and may indicate a somewhat shallower depth for the origin of its containing strata. Stratigraphically intermittent floods of arenaceous forms and of cassidulinids suggest, furthermore, a fluctuation in bottom conditions and colder temperatures.

A return to open-sea conditions is indicated at the base of this interval by the reappearance, in abundance, of *Globigerina.* However, the absence of fossil plankton from the upper two-thirds of this interval suggests a return to the restricted conditions of middle San Lorenzo time.

Lower Vaqueros Faunule

Bulimina-Cibicides Faunule.—Again the bathyal district is indicated, for these highest strata in the section studied, by the persistence of most of the forms with apparent deep-water optima that were conspicuous in the preceding interval. The appearance of *Bulimina rinconensis,* a costate form similar to *B. inflata,* which is reported as widely distributed in North Pacific waters and elsewhere at bathyal and abyssal depths by Cushman (1911, p. 84), further supports this contention.

The complete absence of planktonic forms in this faunule suggests that the local restriction from open-sea connections that prevailed during deposition of the uppermost part of the San Lorenzo formation persisted at least through deposition of the lower Vaqueros formation in this region.

Summary of Paleoecology

From the foregoing discussion it may be supposed that during late Butano time the depositional environment of the area studied was that of the marine bathyal district under open-sea conditions, gradually shallowing at about the time represented by the horizon of the Butano–San Lorenzo contact to neritic depths and remaining so until middle San Lorenzo time, with open-sea conditions interrupted just before that time. During the middle San Lorenzo deposition, some restriction from the open seas continued, and a return to bathyal depths is indicated. In fact, relief may very well have been accentuated regionally throughout the Coast Ranges late in this period, in view of the fact that foraminiferal early and middle Refugian

SPECIES
BUTANO FM
SAN LORENZO FORMATION
VAQUEROS FM.
B-2228
B-2229
B-2230
B-2231
B-2232
B-2233
B-2234
B-2235
B-2236
B-2237
B-2238
B-2239
B-2240
B-2241
B-2242
B-2243
B-2244
B-2245
B-2246
B-2247
B-2248
B-2249
B-2250
B-2251
B-2252
B-2253
B-2254
B-2255
B-2256
B-2257
B-2258
B-2259
B-2260
B-2261
B-2262
B-2263
B-2264
B-2265
B-2266
B-2267
B-2268
B-2269
B-2270
B-2271
B-2272
B-2273
B-2274
B-2275
B-2276
B-2277
Ammobaculites cubensis Cushman and Bermudez
Ammobaculites sp
Amphimorphina ignota Cushman and Siegfus
Amphimorphina aff ignota Cushman and Siegfus
Amphimorphina jenkinsi (Church)
Amphimorphina cf jenkinsi (Church)
Angulogerina occidentalis Cushman
Angulogerina cf wilcoxensis (Cushman and Ponton)
Angulogerina sp
Anomalina californiensis Cushman and Hobson
Anomalina garzaensis Cushman and Siegfus
Anomalinoides cf globosa Brotzen
Asterigerina crassaformis Cushman and Siegfus
Bathysiphon eocenica Cushman and G Hanna
Bathysiphon sanctaecrucis Cushman and Kleinpell
Bifarina eleganta (Plummer)
Bolivina gracilis Cushman and Applin
Bolivina gracilis incisurata Cushman
Bolivina kleinpelli Beck
Bolivina marginata Cushman
Bolivina pisciformis Galloway and Morrey
Bolivinoides mexicanus (Cole)
Bulimina guayabalensis ampla Cushman and Parker
Bulimina cf kugleri Cushman and Renz
Bulimina microcostata Cushman and Parker
Bulimina ovata d'Orbigny
Bulimina rinconensis Cushman and Laiming
Bulimina sculptilis Cushman
Bulimina cf socialis Bornemann
Bulimina cf stalacta Cushman and Parker
Buliminella curta Cushman
Buliminella subfusiformis Cushman
Cancris mexicanus Cushman and Todd
Cassidulina crassipunctata Cushman and Hobson
Cassidulina cf diversa Cushman and Stone
Cassidulina globosa Hantken
Cassidulinoides californiensis Bramlette
Chilostomella hadleyi Keijzer
Chilostomelloides oviculo Nuttall
Chilostomelloides oviformis (Sherborn and Chapman)
Cibicides cushmani Nuttall
Cibicides falconensis Renz
Cibicides hodgei Cushman and Schenck
Cibicides pseudoungerianus evolutus Cushman and Hobson
Cibicidoides cf midwayensis (Plummer)
Cyclammina clarki (Hanna)
Cyclammina cf C incisa Stache
Cyclammina samanica W Berry
Dorbyella sp
Dentalina cf catenula Reuss
Dentalina colei Cushman and Dusenbury
Dentalina consobrina d'Orbigny
Dentalina cooperensis Cushman
Dentalina cf hantkeni Cushman
Dentalina jarvisi Cushman and Todd
Dentalina cf legumen Reuss
Dentalina nasuta Cushman
Dentalina pauperata (d'Orbigny)
Dentalina pioneerensis Kleinpell
Dentalina quadrulata Cushman and Laiming
Dentalina spinosa d'Orbigny
Dentalina sp
Discammina ? eocenica Mallory
Dorothia californica Cushman and Kleinpell
Eggerella elongata Blaisdell MS
Eggerella ihungia Finlay
Eggerella subconica Parr
Eggerella(?) cf trochoides (Reuss)
Eggerella sp
Ellipsonodosaria cf alexanderi Cushman
Ellipsonodosaria atlantisae Cushman
Ellipsonodosaria (?) cf jarvisi Cushman
Ellipsonodosaria cf nuttalli Cushman and Jarvis
Ellipsonodosaria recta Palmer and Bermudez
Ellipsonodosaria spinulosa (Montagu)
Ellipsonodosaria "sp. A" Cushman and Siegfus
Elphidium cf californicum Cook MS
Enantiodentalina obliquisuturata (Stache)
Entosolenia cf apiculata (Reuss)
Eponides keenani Cushman and Kleinpell
Eponides kleinpelli Cushman and Frizzell
Eponides lodoensis martini Smith
Eponides cf mexicana Cushman
Eponides umbonatus (Reuss)
Epistomina eocenica Cushman and M Hanna
Epistomina ramonensis Cushman and Kleinpell
Frondicularia tenuissima Hantken
Gaudryina laevigata Franke
Gaudryina sp
Globigerina decepta Martin
Globigerina ouachitaensis Howe and Wallace
Globigerina triloculinoides Plummer
Globigerinella micra (Cole)
Globobulimina cf. pacifica Cushman
Globorotalia crassata aequa Cushman and Renz
Guttulina irregularis d'Orbigny
Guttulina problema d'Orbigny
Gyroidina condoni (Cushman and Schenck)
Gyroidina orbicularis d'Orbigny var planata Cushman
Gyroidina planulata Cushman and Renz
Hantkenina alabamensis Cushman
Hantkenina dumblei Weinzierl and Applin
Haplophragmoides deflata n sp
Haplophragmoides flagleri trinitatensis Cushman and Renz
Haplophragmoides kirki Wickenden
Haplophragmoides obliquicameratus Marks
Hopkinsina compressa (Cushman)
Hyperammina elongata ? Brady
Karreriella barbati Cushman
Karreriella media-aguaensis Mallory
Karreriella washingtonensis Rau
Lagena becki n sp
Lagena conscripta Cushman and Barksdale
Lagena hexagona Williamson
Lagena strumosa Reuss
Lagena cf substriata Williamson
Lagena vulgaris Williamson
Lenticulina cf convergens (Bornemann)
Marginulina cf adunca (Costa)
Marginulina alazanensis Nuttall
Marginulina eximia Neugeboren
Marginulina cf inconspicua Hussey
Marginulina munda Cushman
Martinottiella eocenica Cushman and Bermudez
Nodogenerina adolphina (d'Orbigny)
Nodogenerina advena Cushman and Laiming
Nodogenerina sanctaecrucis Kleinpell
Nodogenerina wegemanni (Cole)
Nodogenerina sp
Nodosaria anomala Reuss
Nodosaria ewaldi Reuss
Nodosaria holserica Schwager
Nodosaria longiscata d'Orbigny
Nodosaria parexilis sentifera Cushman and Parker
Nodosaria pyrula d'Orbigny
Nodosaria cf soluta (Reuss)
Nonion cf labradoricum Dawson
Nonionella cf miocenica Cushman
Orbulina universa d'Orbigny
Pelosina complanata Franke
Planularia caribbeana Bermudez
Planularia tolmani Cushman and Simonson
Planulina haydoni Cushman and Schenck
Plectina garzaensis Cushman and Siegfus
Plectina cf ruthenica (Reuss)
Plectofrondicularia cf basi-spinata Cushman
Plectofrondicularia kerni (Cook) MS
Plectofrondicularia minuta n sp
Plectofrondicularia miocenica Cushman
Plectofrondicularia cf. oregonensis Cushman, R.E and K.C Stewart
Plectofrondicularia packardi multilineata Cushman and Simonson
Plectofrondicularia packardi packardi Cushman and Schenck
Plectofrondicularia searsi Cushman, R.E and K.C Stewart
Plectofrondicularia trinitatensis Cushman and Jarvis
Plectofrondicularia vaughani Cushman
Plectofrondicularia cf vaughani Cushman
Plectofrondicularia virginiana Cushman and Cederstrom
Plectofrondicularia vokesi Cushman, R.E. and K.C Stewart
Pseudoglandulina cf manifesta (Reuss)
Pseudoglandulina ovata (Cushman and Applin)
Pseudoglandulina sp
Pullenia eocenica Cushman and Siegfus
Pullenia quinqueloba angusta Cushman and Todd
Quinqueloculina minuta Beck
Quinqueloculina triangularis d'Orbigny
Rectoguembelina cf trinitatensis Cushman and Renz
Reophax cf pilulifer H.B. Brady
Rhabdammina eocenica Cushman and G Hanna
Robulus cf adelinensis Keijzer
Robulus alato-limbatus (Gümbel)
Robulus antipodum (Stache)
Robulus arcuato-striatus carolinianus Cushman
Robulus cf calcar (Linne)
Robulus chiranus Cushman and Stone
Robulus clericii acies Cushman and Renz
Robulus cf clypeiformis d'Orbigny
Robulus cultratus Montfort
Robulus cf deformis (Reuss)
Robulus inornatus (d'Orbigny)
Robulus insuetus Cushman and Stainforth
Robulus kincaidi Beck
Robulus cf limbosus hockleyensis (Cushman and Applin)
Robulus mayi Cushman and Parker
Robulus midwayensis (Plummer)
Robulus propinquus cowlitzensis Beck
Robulus simplex d'Orbigny
Robulus cf R terryi Coryell and Embich
Robulus vortex (Fichtel and Moll)
Robulus wormani Barbat and von Estorff
Robulus sp
Saracenaria ? cf S acutiauricularis (d'Orbigny)
Saracenaria hantkeni (Cushman)
Siphogenerina cf smithi Kleinpell
Sphaeroidina gredalensis Cook MS.
Spiroloculina lamposa Hussey
Spiroloculina wilcoxensis Cushman and Garrett
Spiroplectammina eocenica (Cushman and Barksdale)
Stichocassidulina cf S thalmanni Stone
Textularia cf warreni Cushman and Ellisor
Trochammina albertensis Wickenden
Trochammina diagonis (Carsey) Cushman and Waters
Uvigerina atwilli Cushman and Simonson
Uvigerina auberiana d'Orbigny
Uvigerina gallowayi Cushman
Uvigerina garzaensis Cushman and Siegfus
Uvigerina garzaensis nudo-robusta Mallory
Uvigerinella obesa impolita Cushman and Laiming
Valvulineria tumeyensis Cushman and Simonson
Valvulineria tumeyensis conica n var
Valvulineria cf wilcoxensis Cushman and Ponton
Virgulina bramlettei Galloway and Morrey
Virgulina californiensis Cushman
Virgulina dibollensis Cushman and Applin
Vulvulina curta Cushman and Siegfus
DISTANCE IN FEET ABOVE AND BELOW THE BASE OF THE SAN LORENZO FORMATION
-145
-116
-108
28
130
197
258
304
354
370
372
374
382
495
507
557
593
583
627
643
662
706
732
757
813
855
892
975
983
1102
1130
1154
1211
1240
1308
1370
1408
1518
1638
1666
1692
1692
1700
1700
1712
1764
1791
1807
2055
AMPHIMORPHINA FAUNULE
VALVULINERIA FAUNULE
ELLIPSONODOSARIA FAUNULE
EGGERELLA FAUNULE
GLOBIGERINA ZONULE
BULIMINA-VALVULINERIA ZONULE
BULIMINA-PLECTOFRONDICULARIA FAUNULE
PLANULINA-PLECTOFRONDICULARIA ZONULE
VIRGULINA-PLECTOFRONDICULARIA FAUNULE
CASSIDULINOIDES FAUNULE
CYCLAMMINA ZONULE
LOWER CASSIDULINA ZONULE
BOLIVINA ZONULE
UVIGERINELLA ZONULE
UPPER CASSIDULINA FAUNULE
EPONIDES FAUNULE
ROBULUS FAUNULE
BULIMINA-CIBICIDES FAUNULE
STRATIGRAPHIC DISTRIBUTION OF FORAMINIFERA IN THE TYPE SECTION OF THE SAN LORENZO FORMATION.
LEGEND
RARE
FEW
COMMON
ABUNDANT

To accompany Frank R. Sullivan, "Foraminifera from the Type Section of the San Lorenzo Formation, Santa Cruz County, California," Univ. Calif. Publ. Geol. Sci., Vol. 37, No. 4

Fig. 5. Stratigraphic distribution of Foraminifera in the Type Section of the San Lorenzo formation.

strata originating at medium depth pass upward into late Refugian shallower-water deposits (lower Alegria, upper San Emigdio–lower Pleito, Tunnel Point sandstone, Pittsburg Bluff sandstone, Lincoln formation) in many areas; whereas, here in the region of the type San Lorenzo formation, they pass upward into deep-water late Refugian and early Zemorrian deposits. Throughout late San Lorenzo and earliest Vaqueros time the bathyal district proper seems to have prevailed in this area, with a temporary return of open-sea conditions early in the interval but with some restriction from open-ocean currents developing once more late in San Lorenzo and persisting into Vaqueros time.

The far greater number of species and fewer individuals present in the *Amphimorphina* Faunule compared to those in the later faunas of comparable depth of origin, together with the rise in abundance of the cassidulinids higher in the section, suggests a local temperature change that is in keeping with the widespread change known, from other lines of evidence, to have occurred in this general region through this geochronologic interval, i.e., a change from the generally warmer temperatures known to have prevailed here during Eocene time to the somewhat cooler conditions that followed in middle Oligocene time.

AGE

EARLY CORRELATIONS OF THE LOCAL BUTANO, SAN LORENZO, AND VAQUEROS FORMATIONS

The San Lorenzo formation was originally described as Oligocene in age on the basis of its stratigraphic position below sandstone beds believed to be of lower Miocene age, and because of the mixing of Tejon (Eocene) and Monterey (Miocene) species contained within its marine invertebrate fauna (Arnold, 1906, p. 16).

Clark (1918, pp. 53–55) accepted Arnold's age designation for the San Lorenzo formation and proposed the term "San Lorenzo series" to include all known West Coast beds referred to the Oligocene. He was careful to point out, however, that the West Coast Tejon (upper Eocene) fauna was not known to represent the uppermost Eocene as recognized farther each in the Gulf region, thus leaving an unaccounted-for time interval. Clark here suggested the possibility that the West Coast faunas referred to the Oligocene might be, in part, upper Eocene. After reviewing the paleontological data of the type San Lorenzo section (1930, p. 758), he proposed to discard the name "San Lorenzo" as a general one for the Oligocene series because of the poor preservation and small number of species in the fauna.

The first Foraminifera studied and published upon from the San Lorenzo formation were collected along Kings Creek by Valentine (1928, pp. 1–2). Although the species found appeared to be closely related to California Eocene and Oregon Oligocene species, only a few samples were collected and specific determinations were not made.

The first publications dealing in detail with Foraminifera from the San Lorenzo were those of Hobson and of Cushman and Hobson. The fauna from the upper third of the formation was assigned to the Oligocene series (Hobson, 1932, p. 37; Cushman and Hobson, 1935, p. 54) on the basis of what appeared to be the close affinities of this fauna with "certain strata on the Pacific Coast whose ages have been considered as younger than Tejon (Eocene) and older than Monterey (Miocene)."

In proposing their Refugian Stage, Schenck and Kleinpell (1936, p. 219) included within that stage the lower and middle San Lorenzo formation. This age determination was no doubt strongly influenced by the finding of *"Plectofrondicularia" jenkinsi* in the uppermost part of the subjacent Butano formation (Schenck, 1936, p. 72).

Forrest (1937, p. 326) assigned the upper 2,500 feet of the San Lorenzo to the Zemorrian Stage on the basis of its foraminiferal fauna, an age designation attributed to Kleinpell as early as 1935 by Cushman and Hobson (p. 54), and made by Kleinpell himself in 1938 (pp. 160–161).

In discussing the lowermost typical San Lorenzo, Kleinpell (1938, p. 161) pointed out that the age was not clearly defined, but that the uppermost part of the subjacent Butano formation seemed "to represent the uppermost part of the pre-Refugian Eocene . . ."; and he noted that further detailed study of the stratigraphic relations in the area was being undertaken by Forrest.

Finally, a note by Forrest and Schenck (Weaver *et al.*, 1944, p. 580) assigned the lower 680 feet of the San Lorenzo formation to the Refugian and "unnamed" stages, and the upper 2,275 feet to the Zemorrian.

All these conclusions in regard to the age of the San Lorenzo formation were in keeping with those assumed for the subjacent Butano and the superjacent Vaqueros formations.

The sandstone underlying the San Lorenzo formation, though believed to be unfossiliferous in general, had at first been questionably referred to the Oligocene by Arnold (1908, p. 348). This age assignment was based on a small mollusk fauna found just south of the mouth of Pescadero Creek in an isolated sandstone outcrop, supposedly of the same subjacent sandstone formation, but actually of uncertain stratigraphic relationship. In the following year the main body of sandstone clearly underlying the typical San Lorenzo was described by Branner, Newsom, and Arnold (1909, p. 3) as the type for a new formation, the Butano. And because of its conformable position below the San Lorenzo formation, which was believed at that time to be well up in the Oligocene, the Butano sandstone also was presumed to be of Oligocene age.

However, as later found by Hobson, Kleinpell, and Schenck, the presence in the upper Butano of *"Plectofrondicularia" jenkinsi,* recorded previously only from the Markley formation, suggested a possible late Eocene age or that of "the stage below the Refugian" (Schenck, 1936, p. 69; Schenck and Kleinpell, 1936, p. 223) for at least this upper part of the Butano formation.

Forrest (1943, chart) appears to have concurred in this correlation; and a year later the upper limit of the Butano formation was considered by Forrest and Schenck (Weaver *et al.*, 1944, p. 580) as falling *in* the *"Plectofrondicularia jenkinsi* zone" or thus *within* the upper part of the "unnamed stage" just below the Refugian.

The overlying Vaqueros formation as developed in the type San Lorenzo area was early noted for the small number of its fossil localities. These nonetheless yielded "an abundant fauna of unmistakable lower Miocene age" (Branner, Newsom, and Arnold, 1909, p. 4).

Hobson (1932, p. 33) referred to this age designation as unsatisfactory, however, since "no diagnostic fossils were found in the strata referred to the . . . Vaqueros at the type locality of the San Lorenzo formation." And although Loel and Corey (1932, p. 123) reported characteristic lower Miocene megafossils from Vaqueros sandstones of the Santa Cruz Mountains, the fauna was collected from outcrops of the upper part of the Vaqueros formation in the Mindego Hill district north of Butano Ridge. Subsequently the lower part of the Vaqueros formation in the general area of the type San Lorenzo was assigned by Kleinpell to his Lower Zemorrian Stage, or *Uvigerina gallowayi* Zone, on the basis of foraminiferal evidence (Kleinpell, 1938, p. 161, table x; p. 111), a correlation not in conflict with that of Loel and Corey for the higher beds of the Vaqueros farther north.

Forrest (1937, p. 326; 1944, chart) and Forrest and Schenck (Weaver *et al.*, 1944, p. 580) are in accord with this age determination for the lower Vaqueros of the San Lorenzo River area.

AGE OF THE SAN LORENZO RIVER STRATAL SEQUENCE AS INDICATED BY THE FORAMINIFERA

Butano formation.—On the basis of its contained foraminifers, the upper Butano formation, as exposed along the San Lorenzo River north of Boulder Creek, is of late Eocene age, and appears to represent the *Bulimina corrugata* Zone or lower Narizian Stage in terms of Mallory's classification of the West Coast lower Tertiary (Mallory, 1959, pp. 57–60). This is indicated by the joint occurrence of *Amphimorphina ignota, Bifarina eleganta, Ellipsonodosaria atlantisae* var. *hispidula, Globigerina decepta, Globorotalia crassata* var. *aegua*, and *Plectofrondicularia kerni*, all of which are reported by Mallory as having their highest occurrence in this zone, with *Hantkenina alabamensis, Haplophragmoides obliquicameratus, Robulus insuetus, Saracenaria* cf. *S. acutauricularis, Uvigerina garzaensis*, and *Valvulineria tumeyensis* reported as having their lowest occurrence in this zone. A large number of other species represented here, though stratigraphically less restricted, are nevertheless common also in the Ulitisian Stage and the Narizian Stage (Mallory, 1959).

San Lorenzo formation.—The lowermost 732-foot interval of the typical San Lorenzo appears still to be of late Eocene age, representing the *Amphimorphina jenkinsi* Zone or upper Narizian Stage. *Amphimorphina jenkinsi*, reported by Mallory (1959, p. 61) as restricted to this zone, is present in the lowest sample, and the age assignment indicated by its presence is further substantiated for the entire lower member of the San Lorenzo by the joint occurrence therein of *Bolivina kleinpelli, Bulimina microcostata, Eggerella subconica, Hantkenina dumblei, Plectofrondicularia minuta, P. searsi, P. vokesi, Robulus chiranus, Stichocassidulina* cf. *S. thalmanni*, and *Uvigerina garzaensis* var. *nudorobusta*, all reported by Mallory as having their highest occurrence in this zone, with *Bulimina sculptilis, Cibicides hodgei, Plectofrondicularia packardi* var. *packardi*, and *Virgulina californiensis*, reported as having their lowest occurrence in this upper zone of the Narizian.

The middle part of the San Lorenzo formation, i.e., the interval from 757 to 983 feet above the base of the formation which contains a fauna conspicuously new in the local column, and particularly the 80 feet included between sample B-2252 and sample B-2254, is of latest Eocene or Oligocene age and represents the Refugian Stage as indicated by the presence of *Planulina haydoni* and *Uvigerina atwilli* (the "*Uvigerina* cf. *glabrans*" of older West Coast usage), species restricted to this stage according to Schenck and Kleinpell (1936). *Uvigerina gallowayi,* not known from stratigraphically lower than middle Refugian horizons, appears here throughout the upper two-thirds of this unit. Two other species, conspicuous in most Refugian faunas throughout the Coast Ranges, although they range somewhat lower and higher in the column, are also present in this interval: *Bulimina sculptilis* in the lower sample and *Plectofrondicularia packardi sensu stricto* throughout. Finally, conflicting evidence is presented by the presence, at the base of this interval, of *Robulus chiranus* and *Uvigerina garzaensis* var. *nudo-robusta,* both reported by Mallory (1959, p. 61) as having their highest occurrence in the upper Narizian Stage, and by the presence toward the top of this same interval of *Bolivina marginata,* the lowest recorded occurrences of which have previously been considered (Kleinpell, 1938, pp. 110, 116) Lower Zemorrian. The preponderance of data available at this time suggests that, of the alternatives presented by this conflicting evidence, those involving an upward extension in range of *Robulus chiranus* and *Uvigerina garzaensis* var. *nudo-robusta* (i.e., into the Refugian), and an earlier appearance on the West Coast of *Bolivina marginata* than previously realized, will best accommodate this known evidence. These alternatives are herein accepted.

The upper 1,200-foot interval of the type San Lorenzo appears to represent the *Uvigerina gallowayi* Zone or Lower Zemorrian Stage of Kleinpell (1938, p. 110). Of species collected from this interval, *Epistomina ramonensis* and *Reophax* cf. *R. pilulifer* appear to be restricted to this zone. *Buliminella curta, B. subfusiformis, Nodosaria parexilis sentifera, Nonion* cf. *N. labradoricum, Plectofrondicularia miocenica,* and *Uvigerinella obesa impolita,* also present here, seem, from previous records, to have their lowest occurrence in this zone. *Bathysiphon sanctaecrucis, Bolivina pisciformis, Cassidulina crassipunctata, Cibicides pseudoungerianus* var. *evolutus, Ellipsonodosaria recta, Lagena strumosa,* and *Nodosaria holserica,* also present, appear to have their highest occurrence in this same zone. There is conflicting evidence, however, for such an age assignment because of the presence of *Dentalina quadrulata,* recorded (Kleinpell, 1938) as making its first appearance on the West Coast in the lower Saucesian Stage. Again, an interpretation that would bring this cryptogenetic species into the California region earlier than had previously been supposed (in early Zemorrian rather than early Saucesian time) best accommodates the pertinent evidence now known.

Vaqueros formation.—The foraminiferal fauna of the lower 150 feet of the Vaqueros formation, as exposed in the type San Lorenzo area, is indistinguishable in age from that of the upper San Lorenzo formation. This is indicated by the occurrence of *Bulimina rinconensis* jointly with *Bathysiphon sanctaecrucis, Bulimina* cf. *B. socialis, Cibicides pseudoungerianus* var. *evolutus, Ellipsonodosaria recta, Nodosaria holserica, N.* cf. *N. soluta,* and *Uvigerina gallowayi,* the first species having its lowest occurrence in the *Uvigerina gallowayi* Zone, and the remainder having their highest occurrences in this same zone.

Summary.—The stratigraphic sequence exposed along the San Lorenzo River, ranging from the upper Butano sandstone below through the type San Lorenzo formation and into the lower Vaqueros formation above, apparently represents continuous deposition from late Eocene into "Oligo-Miocene" time. This marine deposition went on from some point within early Narizian (late Eocene) time in the case of the upper Butano, through late Narizian time from around the Butano–San Lorenzo contact up through most of the lower member of the San Lorenzo. It continued through Refugian time when the middle San Lorenzo was deposited, and into early Zemorrian ("Oligo-Miocene") time during which both the upper San Lorenzo and lower Vaqueros formations were deposited.

SYSTEMATIC DESCRIPTIONS

In the following systematic discussion, all synonymy is based on published figures and descriptions, except where otherwise noted. All type and locality numbers used, unless othewise specified, refer to the collections of the Museum of Paleontology of the University of California, where the type material herein treated has been deposited. In general, the grouping and order of Cushman's classification (1948) is followed.

Phylum PROTOZOA

Class SARCODINA Bütschli, 1882

Order FORAMINIFERA d'Orbigny, 1826

Family ASTRORHIZIDAE

Genus *Rhabdammina* M. Sars, 1869

Rhabdammina eocenica Cushman and G. D. Hanna

(Pl. 1, fig. 1)

Rhabdammina eocenica Cushman and G. D. Hanna, 1927, p. 209, pl. 13, fig. 1; Mallory, 1959, pp. 104–105, pl. 1, figs. 1, 2, pl. 27, fig. 1.

Hypotype 43963, Loc. B-2228.

These specimens have been compared with Mallory's types for this species.

Family RHIZAMMINIDAE

Genus *Bathysiphon* M. Sars, 1872

Bathysiphon eocenica Cushman and G. D. Hanna

(Pl. 1, figs. 2, 3)

Bathysiphon eocenica Cushman and G. D. Hanna, 1927, p. 210, pl. 13, figs. 2, 3.

Hypotypes 43741, 43742, Loc. B-2228.

A few specimens typical of this species are restricted here to the Butano formation.

Bathysiphon sanctaecrucis Cushman and Kleinpell
(Pl. 1, fig. 4)

Bathysiphon sanctaecrucis Cushman and Kleinpell, 1934, p. 1, pl. 1, figs. 1, 2.
Bathysiphon sp. (?) Cushman and Hobson, 1935, p. 55, pl. 8, fig. 1.

Hypotype 43743, Loc. B-2277.

These specimens, common in the San Lorenzo formation, have the typically elongate tests of this species.

Family SACCAMMINIDAE

Genus *Pelosina* H. B. Brady, 1879

Pelosina complanata Franke
(Pl. 1, fig. 5, *a, b*)

Pelosina complanata Franke. Frizzell, 1943, p. 336, pl. 55, fig. 4; Cushman, 1946*a*, p. 15, pl. 1, figs. 9–11.

Hypotype 43918, Loc. B-2238.

Family HYPERAMMINIDAE

Genus *Hyperammina* H. B. Brady, 1878

Hyperammina elongata H. B. Brady?
(Pl. 1, fig. 6)

Hyperammina elongata H. B. Brady? Mallory, 1959, p. 106, pl. 1, fig. 8, pl. 27, fig. 2.

Hypotype 43874, Loc. B-2238.

This has been compared with Mallory's types and is believed to be the same.

Family REOPHACIDAE

Genus *Reophax* Montfort, 1808

Reophax cf. *R. pilulifer* H. B. Brady
(Pl. 1, fig. 7)

Reophax cf. *pilulifer* H. B. Brady. Cushman and Hobson, 1935, p. 55, pl. 8, fig. 2, *a, b*.

Test elongate and tapering, composed of coarse material irregularly cemented; about 3 chambers, increasing rapidly; sutures mildly to strongly depressed; terminal aperture with a protruding neck; initial end with a spine.

Hypotype 43962, Loc. B-2267.

These specimens are identical with topotype material from L.S.J.U. locality 989 (Cushman and Hobson, 1935), deposited at the University of California as locality A-4903.

Family AMMODISCIDAE

Genus *Discammina* Lacroix, 1932

Discommina ? eocenica Mallory
(Pl. 1, fig. 8, *a, b*)

Discammina? eocenica Mallory, 1959, pp. 109–110, pl. 1, fig. 18, *a, b*.

Hypotype 43810, Loc. B-2263.

Specimens common in the upper San Lorenzo formation compare well with Mallory's holotype for this species.

Family LITUOLIDAE

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides deflata n. sp.

(Pl. 1, figs. 11; 12, *a*, *b*, *c*)

Test planispiral, completely involute, compressed, umbilical region only slightly if at all depressed, periphery slightly lobulate, very acute, test thinning to form a keel in the most compressed specimens; 6 chambers in adult whorl, increasing regularly in size, slightly depressed; sutures indistinct, showing only as slight radial thickenings between the chambers that are depressed; wall finely arenaceous with much cement, smoothly finished; aperture a narrow slit at base of last-formed chamber.

Holotype length 0.89 mm., breadth 0.72 mm., thickness 0.21 mm.
Holotype 43866, Loc. B-2243.
Paratypes 43867, Loc. B-2239; 43868, Loc. B-2240.
Type locality: Loc. B-2243, San Lorenzo formation.

This species, common in the lower San Lorenzo, differs from *Haplophragmoides excavata* Cushman and Waters, and from *H. compressa* Le Roy in being more compressed, with acute periphery, having fewer chambers in the late-formed whorl, and having chambers less depressed, making the sutures less distinct.

Haplophragmoides flagleri Cushman and Hedberg var. *trinitatensis* Cushman and Renz

(Pl. 1, fig. 14)

Haplophragmoides flagleri Cushman and Hedberg var. *trinitatensis* Cushman and Renz, 1946, p. 18, pl. 2, figs, 2, 3.

Hypotype 43869, Loc. B-2228.

Haplophragmoides kirki Wickenden

(Pl. 1, fig. 13)

Haplophragmoides kirki Wickenden. Cushman, 1946, p. 21, pl. 2, fig. 23, *a*, *b*, *c*; Mallory, 1959, p. 112, pl. 2, fig. 8, *a*, *b*.

Hypotype 43870, Loc. B-2238.

A number of specimens have been compared with Mallory's types and appear to be the same.

Haplophragmoides obliquicameratus Marks

(Pl. 1, figs. 9, *a*, *b*; 10, *a*, *b*)

Haplophragmoides obliquicameratus Marks, 1951, p. 35, pl. 5, fig. 1, *a*, *b*, *c*.

Hypotypes 43871, Loc. B-2228; 43872, Loc. B-2253.

Genus *Cyclammina* H. B. Brady, 1876

Cyclammina clarki (G. D. Hanna)

(Pl. 2, fig. 3)

Cyclammina clarki? (G. D. Hanna). Cushman and Schenck, 1928, p. 303, pl. 42, fig. 1.
Cyclammina cf. *clarki* G. D. Hanna. Cushman and Hobson, 1935, p. 55, pl. 8, fig. 3, *a*, *b*; Smith, 1956, p. 87, pl. 9, fig. 5, *a*, *b*.

Cyclammina clarki (G. D. Hanna). Mallory, 1959, pp. 114–115, pl. 27, fig. 4, *a*, *b*, pl. 39, fig. 4, *a*, *b*.

Hypotype 43784, Loc. B-2277.

The specimens from the San Lorenzo formation compare well with the topotype material from L.S.J.U. locality 1103 (Cushman and Hobson, 1935), deposited at the University of California as locality A-4901. *Cyclammina clarki* (Hanna) of Mallory (1959, p. 114), and *C.* cf. *C. clarki* (Hanna) of Smith (1956, p. 87), also seem to be the same.

Cyclammina cf. *C. incisa* Stache
(Pl. 2, fig. 1, *a*, *b*)

Cyclammina cf. *C. incisa* Stache. Cushman and Hobson, 1935, p. 55, pl. 8, fig. 4, *a*, *b*; Smith, 1956, p. 88, pl. 9, fig. 4, *a*, *b*; Mallory, 1959, p. 115.
Cyclammina incisa (Stache). Kleinpell, 1938, p. 188.

Hypotype 43785, Loc. B-2253.

This species, common in the San Lorenzo formation, has been compared with topotype material from L.S.J.U. localities 1103, 1102, and 989 (Cushman and Hobson, 1935), deposited at the University of California as localities A-4901, A-4902, and A-4903, and with Smith's and Mallory's types.

Cyclammina samanica W. Berry
(Pl. 2, fig. 2)

Cyclammina samanica W. Berry, 1928, p. 393, text fig. 5, *a*, *b*; Cushman and Siegfus, 1942, p. 401, pl. 15, fig. 5; Mallory, 1959, p. 115, pl. 2, fig. 15, *a*, *b*.

Hypotypes 43786, 43787, Loc. B-2238.

These specimens compare with Mallory's hypotype.

Genus *Ammobaculites* Cushman, 1910

Ammobaculites cubensis Cushman and Bermudez
(Pl. 2, figs. 4, *a*, *b*; 5)

Ammobaculites cubensis Cushman and Bermudez, 1937, pp. 106–107, pl. 16, figs. 4, 16–18.

Hypotypes 43723, 43724, Loc. B-2228.

A few specimens of this large and distinctive species were found in the Butano formation.

Ammobaculites sp.
(Pl. 2, fig. 6)

Test medium-sized, much compressed, only last 2 or 3 chambers uncoiled, remainder forming a losely coiled, somewhat trochoid test, only last-formed whorl visible on ventral side, slightly more on dorsal side; chambers distinct, about 12 in last-formed whorl remaining same size, slightly collapsed; sutures distinct as slightly raised radiating ridges; wall coarsely arenaceous with considerable cement, smoothly finished, incorporating a few large grains; aperture terminal, elongate.

Hypotype 43725, Loc. B-2244.

Only one specimen was found.

Family Textulariidae

Genus *Spiroplectammina* Cushman, 1927

Spiroplectammina eocenica (Cushman and Barksdale)

(Pl. 2, fig. 7, *a, b*)

Spiroplectoides eocenica Cushman and Barksdale, 1930, p. 66, pl. 12, fig. 5, *a, b*.
Textularia eocenica (Cushman and Barksdale). Smith, 1957, p. 151, pl. 18, figs. 6, *a, b; 7, a, b*.

Hypotype 44009, Loc. B-2238.

Only a few specimens were found.

Genus *Textularia* Defrance, 1824

Textularia cf. *T. warreni* Cushman and Ellisor

(Pl. 2, figs. 8, *a, b;* 9)

Test wide, much compressed, early portion missing, faces nearly parallel in end view, the center being slightly thicker than the margins and the margins being as thick or slightly thicker than the areas between them and the center; periphery almost squared in end view, lobulate; chambers distinct, low and broad; sutures raised, meeting to form a zigzag median line, slightly curved and almost at right angles to median line; wall smoothly finished with considerable cement; aperture small in median line at base of last-formed chamber.

Hypotypes 44011, Loc. B-2239; 44012, Loc. B-2253.

Two incomplete specimens resemble *Textularia warreni* Cushman and Ellisor, 1931, pp. 51–52, pl. 7, fig. 2, *a, b*.

Genus *Vulvulina* d'Orbigny, 1826

Vulvulina curta Cushman and Siegfus

(Pl. 2, figs. 10, *a, b;* 11, *a, b*)

Vulvulina curta Cushman and Siegfus, 1935, p. 91, pl. 14, figs. 1, *a, b;* 2; Mallory, 1959, pp. 119–120, pl. 3, figs. 12, *a, b;* 13, *a, b;* pl. 27, fig. 6, *a, b*.

Hypotypes 44038, 44039, Loc. B-2228.

A few specimens were found in the Butano formation. Mallory's type for this species is the same.

Family Verneuilinidae

Genus *Gaudryina* d'Orbigny, 1839

Gaudryina laevigata Franke

(Pl. 2, fig. 12, *a, b*)

Gaudryina laevigata Franke. Cushman, 1937*a*, p. 41, pl. 6, figs. 10–17.

Hypotype 43844, Loc. B-2267.

Gaudryina sp.

(Pl. 2, fig. 13 *a, b*)

Hypotype 43845, Loc. B-2275.

Only a few individuals were found in the upper San Lorenzo formation, making a specific identification difficult.

Family Valvulinidae

Genus *Eggerella* Cushman, 1933

Eggerella elongata Blaisdell MS

(Pl. 3, figs. 3; 4, *a, b*)

Hypotypes 43812, 43813, Loc. B-2244; 43814, Loc. B-2245.

This species, well represented in the lower San Lorenzo formation, is conspecific with *Eggerella elongata* Blaisdell (1955, p. 37, pl. 1, fig. 2).

Eggerella ihungia Finlay

(Pl. 3, fig. 1, *a, b*)

Eggerella ihungia Finlay, 1940, Ellis and Messina.

Hypotype 43815, Loc. B-2253.

Eggerella subconica Parr

(Pl. 3, fig. 7)

Eggerella subconica Parr, 1950, Ellis and Messina.

Hypotype 43816, Loc. B-2238.

The San Lorenzo specimens compare well with Parr's figure and description, except in having smooth rather than coarsely arenaceous walls.

Eggerella (?) cf. *E. trochoides* (Reuss)

(Pl. 3, fig. 2, *a, b*)

Hypotype 43817, Loc. B-2244.

A small number of specimens, mostly lacking early chambers, appear to be closely related to *Eggerella* (?) *trochoides* Reuss, of Cushman (1937*b*, p. 46, pl. 5, fig. 1).

Eggerella sp.

(Pl. 3, figs. 5; 6, *a, b*)

Test elongate, only slightly tapering, circular in section, triserial, spirally twisted; 3 chambers in adult whorl, very low, not seeming to increase in height and only slightly in width; sutures depressed; wall coarsely arenaceous, roughly finished; aperture a narrow opening at inner margin of last-formed chamber.

Hypotypes 43818, 43819, Loc. B-2238.

Genus *Dorothia* Plummer, 1931

Dorothia californica Cushman and Kleinpell

(Pl. 4, fig. 1, *a, b*)

Dorothia californica Cushman and Kleinpell, 1934, pp. 1–2, pl. 1, fig. 18, *a, b*.

Hypotype 43811, Loc. B-2277.

Only a single specimen was found.

Genus *Plectina* Marsson, 1878

Plectina garzaensis Cushman and Siegfus

(Pl. 3, figs. 8, *a, b;* 9)

Plectina garzaensis Cushman and Siegfus, 1935, p. 92, pl. 14, figs. 3, 4; Mallory, 1959, p. 126, pl. 4, fig. 13.

Hypotypes 43926, 43927, Loc. B-2228.

The young individuals of this well-represented species from the Butano formation show textularian apertures. The adult forms compare well with Mallory's type.

Plectina cf. *P. ruthenica* (Reuss)

(Pl. 3, figs. 10; 11, *a, b*)

Hypotypes 43928, Loc. B-2266; 43929, Loc. B-2277.

A number of specimens from the upper San Lorenzo resemble the illustrations of *Plectina* cf. *P. ruthenica* (Reuss), of Cushman (1937*b*, p. 105, pl. 11, figs. 10–14).

Genus *Karreriella* Cushman, 1933

Karreriella barbati Cushman

(Pl. 4, fig. 2, *a, b*)

Karreriella barbati Cushman, 1936*c*, p. 37, pl. 5, figs. 14–15.

Hypotype 43875, Loc. B-2273.

A single specimen seems to be identical with Cushman's (fig. 15) illustration of the early triserial stage of this species.

Karreriella media-aquaensis Mallory

(Pl. 4, fig. 5, *a, b*)

Karreriella media-aquaensis Mallory, 1959, p. 127, pl. 5, figs. 5, *a, b;* 6, *a, b*.

Hypotype 43876, Loc. B-2228.

A number of specimens from the Butano formation have been compared with Mallory's material and are the same.

Karreriella washingtonensis Rau

(Pl. 4, figs. 3, *a, b;* 4, *a, b*)

Karreriella washingtonensis Rau, 1948, p. 158, pl. 27, figs. 5, 6.

Hypotypes 43877, 43878, Loc. B-2277.

A few well-preserved specimens were found in the Vaqueros formation.

Genus *Martinottiella* Cushman, 1933

Martinottiella eocenica Cushman and Bermudez

(Pl. 4, fig. 6, *a, b*)

Listerella gracillima Cushman and Bermudez (not *L. communis* (d'Orbigny) var. *gracillima* Cushman). Cushman, 1937*c*, p. 6, pl. 1, figs. 27, 28; Cushman, 1937*b*, p. 140, pl. 16, figs. 16, 17.

Martinottiella eocenica Cushman and Bermudez. Cushman, 1947, p. 48; Mallory, 1959, p. 128, pl. 5, fig. 8, *a, b*.

Hypotype 43898, Loc. B-2228.

These specimens from the Butano formation are the same as Mallory's types for this species.

Family TROCHAMMINIDAE

Genus *Trochammina* Parker and Jones, 1859

Trochammina albertensis Wickenden

(Pl. 4, fig. 7, *a, b*)

Trochammina albertensis Wickenden. Cushman, 1946*a*, p. 50, pl. 15, fig. 7, *a, b, c*.

Hypotype 44013, Loc. B-2240.

Trochammina diagonis (Carsey) Cushman and Waters

(Pl. 4, fig. 8, *a, b*)

Trochammina diagonis (Carsey) Cushman and Waters. Cushman, 1946*a*, p. 49, pl. 15, figs. 1–3.

Test slightly trochoid, evolute, compressed, periphery acute, lobate on well-preserved specimens but only slightly so on average specimens; 6 to 8 chambers in last-formed whorl; sutures slightly curved on dorsal side, radial on ventral side, slightly depressed, not very distinct; wall finely arenaceous.

Hypotype 44014, Loc. B-2237.

Family MILIOLIDAE

Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina minuta Beck

(Pl. 4, fig. 11, *a, b, c*)

Quinqueloculina minuta Beck. Detling, 1946, p. 352, pl. 46, fig. 4, *a, b, c*.

Hypotype 43959, Loc. B-2272.

Quinqueloculina triangularis d'Orbigny

(Pl. 4, fig. 12, *a, b, c*)

Quinqueloculina triangularis d'Orbigny. Cushman and M. A. Hanna, 1927, pp. 57, 58, pl. 6, figs. 8, 9; Smith, 1957, p. 155, pl. 19, figs. 7, *a, b, c*.

Hypotype 43960, Loc. B-2271.

These specimens are conspecific with Smith's types.

Genus *Spiroloculina* d'Orbigny, 1826

Spiroloculina lamposa Hussey

(Pl. 4, fig. 10, *a, b*)

Spiroloculina lamposa Hussey, 1949, p. 121, pl. 26, fig. 6.
Spiroloculina ? cf. *S. lamposa* Hussey. Smith, 1957, p. 155, pl. 18, fig. 11, *a, b;* Mallory, 1959, p. 131, pl. 5, fig. 13, *a, b*, pl. 36, fig. 6, *a, b*.

Hypotype 44006, Loc. B-2228.

A few specimens from the Butano formation are the same as the Smith and Mallory types.

Spiroloculina wilcoxensis Cushman and Garrett
(Pl. 4, fig. 9)

Spiroloculina wilcoxensis Cushman and Garrett, 1939, pp. 78, 79, pl. 13, figs. 5, 6; Cushman and Todd, 1944, p. 13, pl. 3, fig. 8; Cushman and Simonson, 1944, pl. 30, figs. 4–6.

Hypotypes 44007, Loc. B-2239; 44008, Loc. B-2241.

These specimens have a small test, slightly concave at least in the early portion, with a rounded periphery, limbate sutures, and a small rounded aperture, typical of this species.

Family LAGENIDAE

Genus *Robulus* Montfort, 1808

Robulus cf. *R. adelinensis* Keijzer
(Pl. 5, fig. 1, *a*, *b*)

Hypotype 43964, Loc. B-2264.

A few rare specimens appear to compare favorably with *Robulus adelinensis* Keijzer, 1945 (Ellis and Messina).

Robulus alato-limbatus (Gümbel)
(Pl. 7, fig. 9, *a*, *b*)

Robulus alato-limbata (Gümbel). Bandy, 1949, p. 58, pl. 8, fig. 1, *a*, *b*; Todd and Kniker, 1952, p. 13, pl. 2, fig. 23.

Hypotypes 43965, 43966, Loc. B-2228.

Robulus antipodum (Stache)
(Pl. 7, fig. 10, *a*, *b*)

Robulus antipodum (Stache). Cushman and Dusenbury, 1934, p. 53, pl. 7, fig. 5, *a*, *b*; Mallory, 1959, p. 134, pl. 6, fig. 12, *a*, *b*.

Hypotype 43967, Loc. B-2264.

These specimens compare well with Mallory's types.

Robulus arcuato-striatus (Hantken) var. *carolinianus* Cushman
(Pl. 7, fig. 8, *a*, *b*)

Robulus arcuato-striatus (Hantken) var. *carolinianus* Cushman, 1933, p. 4, pl. 1, fig. 9, *a*, *b*; Graham and Classen, 1955, p. 16, pl. 2, fig. 41, *a*, *b*.

Hypotype 43968, Loc. B-2264.

Robulus cf. *R. calcar* (Linné)
(Pl. 5, fig. 4, *a*, *b*)

Robulus cf. *calcar* (Linné). Kleinpell, 1938, p. 197, pl. 3, fig. 6.

Hypotype 43969, Loc. B-2277.

A few well-preserved specimens were found in the Vaqueros material.

Robulus chiranus Cushman and Stone
(Pl. 7, figs. 1; 2, *a*, *b*)

Robulus chiranus Cushman and Stone, 1947, p. 5, pl. 1, fig. 15; Cushman, Stewart, and Stewart, 1947*a*, p. 98, pl. 12, fig. 5, *a*, *b*; 1949, p. 130, pl. 14, fig. 3, *a*, *b*.

Robulus aff. *warmani* Barbat and von Estorff. Wilson, 1954, p. 135, pl. 14, fig. 5, *a*, *b*.
Robulus aff. *R. welchi* Church. Smith, 1956, p. 89, pl. 10, fig. 6, *a*, *b*.

Hypotypes 43970, Loc. B-2247; 43971, Loc. B-2251.

This small, distinctive species is frequently confused with *Robulus welchi* Church.

Robulus clericii (Fornasini) var. *acies* Cushman and Renz

(Pl. 6, fig. 2, *a*, *b*)

Robulus clericii (Fornasini) var. *acies* Cushman and Renz, 1947, p. 11, pl. 3, fig. 2.

Hypotypes 43972, 43973, Loc. B-2228.

Robulus cf. *R. clypeiformis* d'Orbigny

(Pl. 6, fig. 5, *a*, *b*)

Robulus cf. *clypeiformis* d'Orbigny. Kleinpell, 1938, p. 197, pl. 3, fig. 7.

Hypotype 43974, Loc. B-2228.

Robulus cultratus Montfort

(Pl. 5, figs. 2, *a*, *b*; 3, *a*, *b*)

Robulus cultratus Montfort. Cushman, 1927*b*, p. 151, pl. 23, fig. 7; Sandidge, 1932, p. 271, pl. 41, figs. 19, 20.
Robulus barbati Cushman and Hobson, 1935, p. 57, pl. 8, fig. 9, *a*, *b*.
Robulus inornatus (d'Orbigny). Smith, 1956, pp. 88–89 (in part), pl. 7, fig. 8, *a*, *b*.
Robulus cf. *R. chehalisensis* Rau. Smith, 1957, p. 157, pl. 20, fig. 3, *a*, *b*.
Robulus pseudocultratus Cole. Mallory, 1959, p. 140, pl. 7, fig. 10, *a*, *b*, pl. 27, fig. 10, *a*, *b*.

Hypotypes 43975, Loc. B-2263; 43976, Loc. B-2277.

These specimens from the upper San Lorenzo and the types of H. P. Smith, B. Y. Smith, and Mallory cited in the synonomy all appear to be the same.

Robulus cf. *R. deformis* (Reuss)

(Pl. 7, fig. 7, *a*, *b*)

Robulus cf. *R. deformis* (Reuss). Galloway and Morrey, 1929, p. 21, pl. 2, fig. 11, *a*, *b*; Mallory, 1959, p. 136, pl. 6, fig. 18, *a*, *b*.

Hypotypes 43977, 43978, Loc. B-2277.

A number of small specimens are characterized by 2 chambers starting to coil, a large proloculum with a peripheral keel starting at the proloculum, and a vertical slit for an aperture at the peripheral end of the apertural face, typical of this species, and of Mallory's types.

Robulus inornatus (d'Orbigny)

(Pl. 5, fig. 5, *a*, *b*)

Robulus inornata (d'Orbigny). Cushman and Schenck, 1928, p. 307, pl. 42, fig. 3, *a*, *b*.
? *Robulus inornatus* (d'Orbigny). Cushman and Barksdale, 1930, p. 62, pl. 11, figs. 2, 3.
Robulus inornatus (d'Orbigny). Toulmin, 1941, p. 557, pl. 78, fig. 19; Beck, 1943, p. 595, pl. 104, figs. 1–4; Cushman and Todd, 1946, p. 48, pl. 7, fig. 9; Cushman, Stewart, and Stewart, 1947*a*,

p. 97, pl. 13, fig. 2, *a, b;* 1947*b*, p. 60, pl. 7, fig. 3, *a, b;* Wilson, 1954, p. 134, pl. 13, fig. 6, *a, b;* Smith, 1957, pp. 157–158, pl. 20, figs. 7–11; Mallory, 1959, p. 137, pl. 7, fig. 15, *a, b.*

Robulus cf. *R. inornatus* (d'Orbigny). Smith, 1957, p. 158, pl. 20, fig. 14, *a, b.*

Hypotypes 43979, 43980, 43981, Loc. B-2264.

This species is quite variable, and the types of Wilson, Smith, and Mallory, cited in the synonomy, appear to be the same as the San Lorenzo material.

Robulus insuetus Cushman and Stainforth

(Pl. 5, figs. 6; 7, *a, b*)

Robulus insuetus Cushman and Stainforth. Cushman, 1947, p. 77, pl. 17, fig. 1.

Hypotypes 43982, 43983, Loc. B-2237.

Most of the specimens found compare well with Cushman's 1947 description, but a few are not strongly umbonate and have low sutures.

Robulus kincaidi Beck

(Pl. 7, fig. 4, *a, b*)

Robulus kincaidi Beck, 1943, p. 595, pl. 102, figs. 1, 7; Mallory, 1959, p. 137, pl. 6, fig. 17, *a, b.*

Hypotype 43984, Loc. B-2228.

A single specimen compares well with the type description, the last chamber making up half of the entire test. It differs only in being of medium rather than large size, and the keel is not so pronounced. Mallory's type appears to be the same.

Robulus cf. *R. limbosus* (Reuss) var. *hockleyensis* Cushman and Applin

(Pl. 6, fig. 1, *a, b*)

Hypotype 43985, Loc. B-2263.

Robulus mayi Cushman and Parker

(Pl. 7, fig. 5, *a, b*)

Robulus mayi Cushman and Parker, 1931, p. 2, pl. 1, figs. 3–5.

Robulus cf. *mayi* Cushman and Parker. Cushman and Hobson, 1935, p. 57, pl. 8, fig. 10, *a, b.*

Hypotype 43986, Loc. B-2277.

These Vaqueros specimens appear to be typical of this species.

Robulus midwayensis (Plummer)

(Pl. 6, fig. 3, *a, b*)

Cristellaria midwayensis Plummer, 1926, p. 95, pl. 13, fig. 5.

Robulus midwayensis (Plummer). Cushman, 1940, p. 54, pl. 3, fig. 12; Cushman and Todd, 1946, p. 47, pl. 7, fig. 7; Cushman, 1951, p. 13, pl. 3, figs. 14–17.

Hypotype 43987, Loc. B-2263.

A few specimens, circular in outline, show raised sutures when wet, radiating from a distinct boss.

Robulus propinquus cowlitzensis Beck

(Pl. 6, figs. 6; 7, *a, b;* 8, *a, b*)

Robulus propinquus cowlitzensis Beck, 1943, p. 595, pl. 104, figs. 6, 12.

Test medium-sized, later chambers tending to become elongate but not to uncoil, periphery subacute, slightly keeled; 7 chambers in last-formed whorl, slightly inflated, gradually elongating as added; sutures limbate, flush with surface in early portion, becoming depressed between last few chambers; wall smooth, very finely perforate; apertural face almost flat in young forms becoming broadly convex in adult forms, aperture radiate at peripheral angle, with a distinct vertical slit.

Hypotypes 43988, 43989, 43990, Loc. B-2267.

These upper San Lorenzo specimens appear in a number of samples and seem to be the same as in Beck's illustrations of the type. *Robulus welchi* Church (Detling, 1946, p. 353, pl. 48, fig. 2, *a, b*) appears to be a young form of this species.

Robulus simplex d'Orbigny
(Pl. 5, fig. 8, *a, b*)

Robulus simplex d'Orbigny. Cushman and Laiming, 1931, p. 98, pl. 10, figs. 5, *a, b*, 6.

Hypotypes 43991, 43992, Loc. B-2252.

Robulus cf. *R. terryi* Coryell and Embich
(Pl. 7, fig. 6, *a, b*)

Robulus cf. *R. terryi* Coryell and Embich. Smith, 1957, p. 159, pl. 21, fig. 1, *a, b;* Mallory, 1959, p. 141, pl. 6, fig. 1, *a, b*.

Hypotypes 43993, 43994, Loc. B-2228.

A number of Butano specimens are typical of the Smith and Mallory types in having chambers ending bluntly at the large, clear umbo which permits a view of the early whorls.

Robulus vortex (Fichtel and Moll)
(Pl. 7, fig. 3, *a, b*)

Lenticulina vortex (Fichtel and Moll). White, 1928, p. 199, pl. 28, fig. 6, *a, b*.
Robulus vortex (Fichtel and Moll) (?). Smith, 1957, p. 159, pl. 21, fig. 2, *a, b;* Mallory, 1959, p. 142, pl. 7, fig. 1, *a, b*.

Hypotype 43995, Loc. B-2251.

This species typically has 9 or 10 chambers forming the last whorl, and sutures greatly curved. The Smith and Mallory types are the same as the material treated here.

Robulus warmani Barbat and von Estorff
(Pl. 6, fig. 4, *a, b*)

Robulus nikobarensis (Schwager), var. *warmani* Barbat and von Estorff, 1933, p. 23, fig. 12, *a, b*.
Robulus warmani Barbat and von Estorff. Cushman and Hobson, 1935, p. 56, pl. 8, fig. 8, *a, b*.

Hypotypes 43996, 43997, Loc. B-2261.

Robulus sp.
(Pl. 7, fig. 11, *a, b*)

Hypotypes 43998, 43999, Loc. B-2228.

A few specimens from the Butano formation are characterized by having a test, circular in outline and quite umbonate, numerous (10–12) chambers with strongly curving sutures, and a distinct thin keel.

Genus *Darbyella* Howe and Wallace

Darbyella sp.

(Pl. 8, fig. 1, *a*, *b*)

Hypotype 43788, Loc. B-2277.

A single specimen was found in the Vaqueros material.

Genus *Lenticulina* Lamarck, 1804

Lenticulina cf. *L. convergens* (Bornemann)

(Pl. 8, fig. 2, *a*, *b*)

Hypotypes 43888, 43889, Loc. B-2228.

A few rare specimens resemble the illustrations of *Lenticulina convergens* (Bornemann), of Kleinpell (1938, p. 205, pl. 3, fig. 8).

Genus *Planularia* Defrance, 1824

Planularia caribbeana Bermudez

(Pl. 8, fig. 3, *a*, *b*)

Planularia caribbeana Bermudez, 1949, p. 136, pl. 8, figs. 49, 50.

Hypotypes 43919, 43920, Loc. B-2228.

These strongly compressed specimens have the parallel sides, narrow keel bordered by low keels on either side, elevated sutures, and aperture at the apex of the last chamber, typical of this species. A tube connecting the aperture and the last chamber cavity is visible when specimens are wet, and the three keels are plainly visible when specimens are set on end.

Planularia tolmani Cushman and Simonson

(Pl. 8, fig. 4, *a*, *b*)

Planularia tolmani Cushman and Simonson, 1944, p. 195, pl. 30, figs. 13, 14.

Hypotypes 43921, 43922, Loc. B-2251.

Several broken specimens have the subacute, slightly keeled periphery, and sutures distinctly angled near the periphery, typical of this species.

Genus *Marginulina* d'Orbigny, 1826

Marginulina cf. *M. adunca* (Costa)

(Pl. 8, figs. 10, *a*, *b*; 11)

Hypotypes 43890, Loc. B-2267; 43891, Loc. B-2276.

Marginulina alazanensis Nuttall

(Pl. 8, figs. 7, *a*, *b*; 8, *a*, *b*)

Marginulina alazanensis Nuttall, 1932, p. 13, pl. 3, figs. 3, 7; Rau, 1948, p. 164, pl. 29, fig. 4.
Dentalina communis (?) d'Orbigny. Cushman and Schenck, 1928, p. 307, pl. 42, fig. 8.
Dentalina cooperensis Cushman. Wilson, 1954, p. 135, pl. 14, figs. 8–10.
Marginulina subrecta Franke. Smith, 1956, pp. 89–90, pl. 11, figs. 4, 5, *a*, *b*.

Hypotypes 43892, Loc. B-2252; 43893, Loc. B-2263.

Most of the specimens are broken, revealing an especially thick wall.

Marginulina eximia Neugeboren

(Pl. 8, fig. 9, *a, b*)

Marginulina eximia Neugeboren. Cushman and Ponton, 1932, p. 54, pl. 7, fig. 8, *a, b;* Mallory, 1959, p. 149, pl. 10, fig. 1, *a, b, c.*

Hypotype 43894, Loc. B-2264.

A number of specimens were compared with Mallory's material and are believed to fall within the range of variation of this species.

Marginulina cf. *M. inconspicua* Hussey

(Pl. 8, fig. 6, *a, b*)

Hypotype 43895, Loc. B-2266.

A few specimens are similar to illustrations of *Marginulina inconspicua* Hussey (1949, p. 123, pl. 26, fig. 10).

Marginulina munda Cushman

(Pl. 8, fig. 5, *a, b*)

Marginulina munda Cushman, 1938, p. 34, pl. 5, figs. 11, 12.

Hypotypes 43896, 43897, Loc. B-2228.

Genus *Saracenaria* Defrance, 1824

Saracenaria ? cf. *S. acutiauricularis* (d'Orbigny)

(Pl. 8, fig. 12, *a, b*)

Saracenaria ? cf. *S. acutiauricularis* (d'Orbigny). Mallory, 1959, p. 152, pl. 11, fig. 2, *a, b.*

Hypotype 44000, Loc. B-2228.

Saracenaria hantkeni (Cushman)

(Pl. 8, figs. 13, *a, b;* 14)

Saracenaria arcuata d'Orbigny *hantkeni* Cushman, 1933, p. 4, pl. 1, fig. 9, *a, b;* 1935, p. 17, pl. 5, figs. 6, 7.

Saracenaria hantkeni (Cushman). Beck, 1943, p. 600, pl. 106, figs. 9, 12; Cushman, 1946*b*, p. 14, pl. 3, fig. 21; Detling, 1946, p. 354, pl. 48, fig. 9, *a, b.*

Hypotypes 44001, 44002, Loc. B-2252.

Genus *Dentalina* d'Orbigny, 1826

Dentalina cf. *D. catenula* Reuss

(Pl. 9, fig. 1, *a, b*)

Hypotype 43789, Loc. B-2252.

A few specimens compare best with the illustrations of *Dentalina catenula* Reuss (Cushman, 1946*a*, p. 67, pl. 23, fig. 27). Also *Dentalina consobrina* d'Orbigny (Kleinpell, 1938, p. 210, pl. 17, fig. 4) seems to be similar.

Dentalina colei Cushman and Dusenbury
(Pl. 9, fig. 6, *a, b*)

Dentalina colei Cushman and Dusenbury, 1934, p. 54, pl. 7, figs. 10–12; Beck, 1943, p. 598, pl. 105, fig. 18; Mallory, 1959, p. 162, pl. 12, fig. 9, pl. 41, fig. 3.
Dentalina approximata Reuss. Smith, 1957, p. 164, pl. 22, fig. 5.

Hypotype 43790, Loc. B-2251.

The material here examined was favorably compared with Smith's and Mallory's types.

Dentalina consobrina d'Orbigny
(Pl. 9, figs. 2; 3, *a, b*)

Nodosaria (*Dentalina*) *consobrina* Cushman and M. A. Hanna, 1927, p. 52, pl. 4, figs. 7, 8.
Dentalina consobrina d'Orbigny. Cushman and Dusenbury, 1934, p. 55, pl. 7, figs. 13–15; Kleinpell, 1938, p. 210, pl. 17, fig. 4.

Hypotypes 43791, 43792, 43793, Loc. B-2228.

This species seems to be quite variable. The specimens from the Butano formation all have a bulbous proloculum which may or may not have a basal spine, and a second chamber ranging from slightly longer than broad, with swollen median portion, to three times longer than broad, with sides almost parallel.

Dentalina cooperensis Cushman
(Pl. 9, figs. 4, *a, b*; 5, *a, b*)

Dentalina cooperensis Cushman, 1935, p. 20, pl. 8, figs. 3, 4.

Hypotypes 43794, 43795, Loc. B-2228.

Dentalina cf. *D. hantkeni* Cushman
(Pl. 9, fig. 8, *a, b*)

Hypotype 43796, Loc. B-2267.

A single broken specimen seems to compare well with the illustrations of *Dentalina hantkeni* Cushman (1935, p. 20, pl. 8, figs. 5, 6).

Dentalina jarvisi Cushman and Todd
(Pl. 9, fig. 9, *a, b*)

Dentalina jarvisi Cushman and Todd, 1945, p. 22, pl. 3, fig. 22.

Hypotypes 43797, Loc. B-2252; 43798, Loc. B-2253.

The few specimens present clearly show the translucent and dark-appearing limbate sutures, thinning noticeably toward the outer margin, and the apertural position close to the inner margin, typical of this species.

Dentalina cf. *D. legumen* Reuss
(Pl. 9, fig. 10, *a, b*)

Hypotype 43799, Loc. B-2228.

This single specimen, except for the very oblique early sutures, compares well with *Dentalina legumen* Reuss (Cushman and Renz, 1946, p. 27, pl. 4, fig. 10).

Dentalina nasuta Cushman
(Pl. 9, fig. 12)

Dentalina nasuta Cushman, 1939, p. 57, pl. 10, figs. 10, 11.

Hypotype 43800, Loc. B-2228.

Only a few specimens were found in the Butano formation.

Dentalina pauperata (d'Orbigny)
(Pl. 9, fig. 7)

Nodosaria pauperata d'Orbigny. Plummer, 1926, p. 79, pl. 4, fig. 11.

Dentalina pauperata (d'Orbigny). Cushman and Laiming, 1931, p. 99, pl. 10, figs. 11, 12.

Hypotype 43801, Loc. B-2228.

Dentalina pioneerensis Kleinpell
(Pl. 9, fig. 11, *a*, *b*)

Dentalina pioneerensis Kleinpell, 1938, pp. 213, 214, pl. 4, fig. 7.

Dentalina ? sp. Cushman and Siegfus. Mallory, 1959, p. 168, pl. 12, fig. 28.

Hypotype 43802, Loc. B-2252.

Mallory's type appears to be identical with the San Lorenzo material.

Dentalina quadrulata Cushman and Laiming
(Pl. 9, figs. 13; 14, *a*, *b*)

Dentalina quadrulata Cushman and Laiming, 1931, p. 99, pl. 10, fig. 13; Cushman and Parker, 1931, p. 3, pl. 1, figs. 9–11.

Hypotypes 43803, Loc. B-2266; 43804, 43805, Loc. B-2277.

Most of these specimens, from the upper San Lorenzo and lower Vaqueros formations, have tests with five distinct costae, the later portions of some showing the beginning of additional costae. Only three specimens from the Vaqueros sample are definitely four-sided. Although this species differs from *Nodosaria acuminata* Hantken in having fewer longitudinal costae, the two species appear to be closely related.

Dentalina spinosa d'Orbigny
(Pl. 9, figs. 17, *a*, *b*; 18)

Dentalina spinosa d'Orbigny. Kleinpell, 1938, p. 215, pl. 4, fig. 3; Smith, 1956, p. 91, pl. 10, fig. 10.

Hypotypes 43806, 43807, Loc. B-2228.

A number of broken specimens, consisting of one and two chambers typical of this species, were found in the Butano material.

Dentalina sp.
(Pl. 9, figs. 15; 16, *a*, *b*)

Test elongate, curved; chambers slightly inflated, increasing very slowly in height and little if at all in width; proloculum bulbous and larger than second chamber; sutures limbate, slightly depressed; wall smooth except for spine at initial end; aperture terminal and radiate.

Hypotypes 43808, Loc. B-2264; 43809, Loc. B-2277.

Only broken specimens were found. They seem to compare closely with the illustrations of *Ellipsonodosaria* sp. *B.* of Cushmen and Simonson (1944, p. 200, pl. 33, figs. 8, 9).

Genus *Nodosaria* Lamarck, 1812

Nodosaria anomala Reuss

(Pl. 10, fig. 6, *a, b*)

Nodosaria anomala Reuss. Cushman and Parker, 1931, p. 4, pl. 1, figs. 12–14.
Nodosaria cf. *anomala* Reuss. Cushman and Hobson, 1935, p. 58, pl. 1, fig. 16.

Hypotype 43906, Loc. B-2266.

Nodosaria ewaldi Reuss

(Pl. 10, fig. 7)

Nodosaria ewaldi Reuss. Cushman and Dusenbury, 1934, p. 56, pl. 7, fig. 21.
Nodosaria ewaldi Reuss ? Cushman, 1935*a*, p. 22, pl. 9, fig. 2.

Hypotype 43907, Loc. B-2277.

Nodosaria holserica Schwager

(Pl. 10, fig. 2, *a, b*)

Nodosaria holserica Schwager. Galloway and Morrey, 1929, p. 17, pl. 2, fig. 4; Kleinpell, 1938, p. 218, pl. 4, fig. 9.

Hypotype 43908, Loc. B-2277.

Nodosaria longiscata d'Orbigny

(Pl. 10, fig. 1)

Nodosaria longiscata d'Orbigny. Plummer, 1926, p. 82, pl. 4, fig. 17, *a, b;* Cushman and Todd, 1945, p. 25, pl. 4, figs. 8–10; Cushman and Stainforth, 1945, p. 24, pl. 3, figs. 19–21.
Nodosaria cf. *longiscata* d'Orbigny. Cushman, Stewart, and Stewart, 1947*a*, p. 98, pl. 13, fig. 1.
Hypotype 43909, Loc. B-2228.

Nodosaria parexilis Cushman and Stewart var. *sentifera* Cushman and Parker

(Pl. 10, fig. 8)

Nodosaria parexilis Cushman and Stewart var. *sentifera* Cushman and Parker, 1931, p. 6, pl. 1, fig. 16.

Hypotype 43910, Loc. B-2263.

Nodosaria pyrula d'Orbigny

(Pl. 10, figs. 3, *a, b;* 4, *a, b*)

Nodosaria pyrula d'Orbigny. Cushman and Schenck, 1928, p. 308, pl. 43, figs. 1, 2; Mallory, 1959, p. 172, pl. 13, fig. 19, pl. 41, fig. 2.
Nodosaria cf. *N. pyrula* d'Orbigny. Beck, 1943, p. 599, pl. 105, figs. 19, 21.

Hypotypes 43911, 43912, Loc. B-2228.

Incomplete specimens display one swollen chamber and occasionally a broken portion of another with an elongate slender connection between.

Nodosaria cf. *N. soluta* (Reuss)

(Pl. 10, fig. 5, *a, b*)

Nodosaria cf. *soluta* (Reuss). Kleinpell, 1938, p. 220, pl. 3, fig. 11.

Hypotype 43913, Loc. B-2277.

A few incomplete specimens from the Vaqueros material closely resemble Kleinpell's cited illustration.

Genus *Pseudoglandulina* Cushman, 1929

Pseudoglandulina cf. *P. manifesta* (Reuss)

(Pl. 11, fig. 1, *a, b*)

Pseudoglandulina cf. *manifesta* Reuss. Cushman and Stainforth, 1945, p. 27, pl. 4, fig. 2.

Hypotype 43952, Loc. B-2264.

A single elongate specimen seems to be the same as in the illustration cited.

Pseudoglandulina ovata (Cushman and Applin)

(Pl. 11, figs. 2, *a, b*; 3; 4)

Nodosaria (*Glandulina*) *laevigata* d'Orbigny var. *ovata* Cushman and Applin, 1926, p. 169, pl. 7, figs. 12, 13.

Pseudoglandulina ovata (Cushman and Applin). Mallory, 1959, p. 174.

Hypotypes 43953, Loc. B-2263; 43954, 43955, Loc. B-2277.

This variable species is abundantly represented in the upper San Lorenzo formation.

Pseudoglandulina sp.

(Pl. 11, fig. 5, *a, b*)

Hypotype 43956, Loc. B-2276.

Genus *Lagena* Walker and Jacob, 1798

Lagena becki n. sp.

(Pl. 10, fig. 16, *a, b*)

Lagena sp. *A*. Beck, 1943, p. 602, pl. 107, fig. 26.

Lagena sp. Smith, 1956, p. 92, pl. 10, fig. 4, *a, b*.

Test spherical, of medium size for genus, ranging from 0.20 to 0.36 mm. in diameter, averaging 0.32 mm.; wall calcareous, finely perforate, entire test covered by about 50 fine striae clearly visible on most specimens but indistinct on a few; aperture rounded, at end of a short neck.

Holotype length 0.34 mm., diameter 0.30 mm.
Holotype 43879, Loc. B-2264.
Paratype 43880, Loc. B-2276.
Type locality: Loc. B-2264, San Lorenzo formation.

The spherical test and many fine striae are the distinctive features of this species.

Lagena conscripta Cushman and Barksdale

(Pl. 10, fig. 10, *a, b*)

Lagena isabella (d'Orbigny) var. *conscripta* Cushman and Barksdale, 1930, p. 66, pl. 12, fig. 4.

Lagena conscripta Cushman and Barksdale. Beck, 1943, p. 601, pl. 107, fig. 38.

Lagena acuticosta Reuss. Mallory, 1959, p. 174 (in part), pl. 28, fig. 10, *a, b*, pl. 41, fig. 8, *a, b*.

Hypotype 43881, Loc. B-2267.

These specimens display a definite expanded area at the apertural end which appears almost like a secondary chamber, typical of the species as described by Cushman and Barksdale.

Lagena hexagona (Williamson)

(Pl. 10, fig. 9, *a, b*)

Lagena hexagona (Williamson). Cushman, 1935, p. 23, pl. 9, fig. 10; Mallory, 1959, p. 175, pl. 14, fig. 7.

Hypotype 43882, Loc. B-2258.

Lagena strumosa Reuss

(Pl. 10, figs. 14; 15, *a, b*)

Lagena striata (d'Orbigny) var. *strumosa* Reuss. Cushman, 1918*a*, p. 58, pl. 21, fig. 7.

Lagena strumosa Reuss. Galloway and Morrey, 1929, p. 20, pl. 2, fig. 8; Kleinpell, 1938, p. 226, pl. 12, fig. 16.

Lagena costata (Williamson). Mallory, 1959, p. 175, pl. 14, fig. 3, *a, b*, pl. 41, fig. 7, *a, b*.

Hypotypes 43883, Loc. B-2263; 43884, Loc. B-2264.

These specimens have a subglobose to globose test (mostly globose), a slender neck and basal spine (mostly broken off), and 20–40 costae, typical of the species.

Lagena cf. *L. substriata* Williamson

(Pl. 10, fig. 11, *a, b*)

Lagena cf. *L. substriata* Williamson. Beck, 1943, p. 602, pl. 107, fig. 30.

Hypotype 43885, Loc. B-2267.

Lagena vulgaris Williamson

(Pl. 10, figs. 12, *a, b;* 13)

Lagena vulgaris Williamson. Cushman, 1946*a*, p. 95, pl. 40, fig. 3; Mallory, 1959, p. 176, pl. 14, fig. 9, *a, b*.

Hypotypes 43886, Loc. B-2266; 43887, Loc. B-2277.

Genus *Frondicularia* Defrance, 1824

Frondicularia tenuissima Hantken

(Pl. 11, fig. 6)

Frondicularia tenuissima Hantken. Cushman, 1927*a*, p. 111, pl. 22, fig. 11; Cushman, 1946*a*, p. 15, pl. 4, figs. 3, 4.

Hypotypes 43842, Loc. B-2228; 43843, Loc. B-2267.

Family POLYMORPHINIDAE

Genus *Guttulina* d'Orbigny, 1839

Guttulina irregularis d'Orbigny

(Pl. 11, fig. 8, *a, b, c*)

Guttulina irregularis d'Orbigny. Cushman, 1935*a*, p. 24, p. 9, figs. 13–16; Wilson, 1954, p. 137, pl. 15, fig. 4, *a, b*.

Hypotype 43857, Loc. B-2252.

Guttulina problema d'Orbigny

(Pl. 11, fig. 9, *a, b, c*)

Guttulina problema d'Orbigny. Cushman and Schenck, 1928, p. 310, pl. 43, figs. 9–11; Detling, 1946, p. 354, pl. 48, fig. 11; Smith, 1956, p. 92, pl. 11, fig. 10, *a, b*.

Hypotype 43858, Loc. B-2266.

Genus *Enantiodentalina* Marie, 1941

Enantiodentalina obliquisuturata (Stache)

(Pl. 11, fig. 7, *a*, *b*, *c*)

Dentalina obliquisuturata Stache. Cushman and Dusenbury, 1934, p. 54, pl. 7, figs. 23–25; Mallory, 1959, p. 17, pl. 14, fig. 20.

Hypotype 43831, Loc. B-2252.

Family Nonionidae

Genus *Nonion* Montfort, 1808

Nonion cf. *N. labradoricum* Dawson

(Pl. 11, figs. 11, *a*, *b*; 12)

Hypotypes 43914, Loc. B-2263; 43915, Loc. B-2275.

A single specimen closely resembles the illustrations of *Nonion labradoricum* Dawson (Cushman, 1939*b*, p. 23, pl. 6, figs. 13–16).

Genus *Nonionella* Cushman, 1926

Nonionella cf. *N. miocenica* Cushman

(Pl. 11, fig. 10, *a*, *b*)

Hypotype 43916, Loc. B-2277.

A single poorly preserved specimen from the Vaqueros material seems to belong to this species.

Genus *Elphidium* Montfort, 1808

Elphidium cf. *E. californicum* Cook MS

(Pl. 11, fig. 13, *a*, *b*)

Hypotype 43830, Loc. B-2253.

A few San Lorenzo specimens differ from *Elphidium californicum* Cook (1950, p. 63, pl. 2, fig. 9, *a*, *b*) in having a rounded periphery and fewer chambers, and in not being umbonate. However, they are identical with Mallory's (1959, p. 184, pl. 15, fig. 10, *a*, *b*) type for this species.

Family Heterohelicidae

Genus *Rectogümbelina* Cushman, 1932

Rectogümbelina cf. *R. trinitatensis* Cushman and Renz

(Pl. 12, fig. 1)

Test elongate, biserial in early portion of about 4 chambers, becoming irregularly uniserial in adult portion of 4 chambers which make up four-fifths of test; adult chambers remaining same in diameter but increasing irregularly in height, the last and third chambers being longer than the second-last, slightly inflated; sutures depressed; wall smooth; aperture terminal.

Hypotype 43961, Loc. B-2228.

This single, distinctive specimen seems to differ from *Rectogümbelina trinitatensis* Cushman and Renz (1948, p. 23, pl. 5, fig. 7) only in the irregular arrangement and increase in height of the adult chambers.

Genus *Bolivinoides* Cushman, 1927

Bolivinoides mexicanus (Cole)

(Pl. 12, fig. 2, *a, b*)

Proroporus mexicanus Cole, 1927, p. 26, pl. 1, fig. 19.

Hypotype 43751, Loc. B-2234.

The depressed sutures forming a zigzag line down the center of the test, and the large terminal aperture, characterize this species.

Genus *Plectofrondicularia* Liebus, 1903

Plectofrondicularia cf. *P. basi-spinata* Cushman

(Pl. 12, figs. 3, *a, b*; 4)

Hypotypes 43930, 43931, Loc. B-2263.

The San Lorenzo specimens seem to have the sharp keel, limbate sutures depressed in the later portion of the test, and the chamber arrangement of *Plectofrondicularia basi-spinata* Cushman (1935*b*, p. 79, pl. 12, fig. 11, *a, b*). However, they differ in that the costae covering the proloculum do not project at the base in short spines.

Plectofrondicularia kerni (Cook) MS

(Pl. 13, figs. 6–8)

Plectofrondicularia kerni Cook. Mallory, 1959, pp. 212–213, pl. 18, fig. 2, pl. 33, fig. 10, *a, b*.

Hypotypes 43932, 43933, 43934, Loc. B-2228.

These specimens from the Butano formation compare favorably with the types of *Amphimorphina kerni* Cook (1950, pp. 65, 66, pl. 2, figs. 2, 3), and with the specimens of this species included on his assemblage slides A-5360–6 and A-5360–A8. The species is quite variable; some specimens have parallel sides; others taper slightly.

Plectofrondicularia minuta n. sp.

(Pl. 13, figs. 1–4)

Test small, twice as long as broad, compressed, periphery subacute and strongly spinose in most specimens; chambers biserial through more than half of test, somewhat inflated, peripheral angles extending into spines; sutures depressed; wall smooth, finely perforate; aperture terminal and elliptical.

Holotype length 0.40 mm., breadth 0.22 mm., thickness 0.08 mm.
Holotype 43935, Loc. B-2236.
Paratypes 43936, 43937, Loc. B-2236; 43938, Loc. B-2242.
Type locality: Loc. B-2236, San Lorenzo formation.

This species differs from *Plectofrondicularia packardi* var. *spinata* Cushman and Schenck in its much smaller size, and greater proportion of biserially arranged chambers, and from *P. dentifera* Cushman and Stainforth in its depressed sutures.

Plectofrondicularia miocenica Cushman
(Pl. 12, fig. 6)

Plectofrondicularia miocenica Cushman, 1926*b*, p. 58, pl. 7, figs. 10, 11; Cushman and Stevenson, 1948, p. 55, pl. 9, fig. 18; Smith, 1956, p. 94, pl. 12, fig. 8.

Hypotypes 43939, Loc. B-2261; 43940, Loc. B-2277.

These specimens from the upper San Lorenzo are smaller and less robust, and increase in width more gradually than *Plectofrondicularia packardi packardi.*

Plectofrondicularia cf. *P. oregonensis* Cushman, Stewart, and Stewart
(Pl. 13, fig. 5)

Hypotype 43941, Loc. B-2243.

A few specimens seem to be the same as *Plectofrondicularia oregonensis* Cushman, Stewart, and Stewart (1947*d*, p. 77, pl. 10, fig. 4).

Plectofrondicularia packardi Cushman and Schenck var. *multilineata* Cushman and Simonson
(Pl. 12, fig. 10)

Plectofrondicularia packardi Cushman and Schenck var. *multilineata* Cushman and Simonson, 1944, p. 197, pl. 32, figs. 2–4; Detling, 1946, p. 355, pl. 49, figs. 3, 5.

Hypotype 43942, Loc. B-2255.

This species seems to grade into *Plectofrondicularia miocenica* Cushman in the upper part of the San Lorenzo formation.

Plectofrondicularia packardi packardi Cushman and Schenck
(Pl. 12, figs. 11, 12)

Plectofrondicularia packardi Cushman and Schenck, 1928, p. 311, pl. 43, figs. 14, 15; Cushman and Simonson, 1944, p. 197, pl. 31, figs. 17, 18, pl. 32, fig. 1; Detling, 1946, p. 355, pl. 49, fig. 1.
Plectofrondicularia packardi packardi Cushman and Simonson. Smith, 1956, p. 94, pl. 12, figs. 1, 7.

Hypotypes 43943, 43944, Loc. B-2252.

The San Lorenzo specimens have been compared with Cushman and Schenck's holotype for this species (U.C. type 31430), and are conspecific.

Plectofrondicularia searsi Cushman, Stewart, and Stewart
(Pl. 13, fig. 9)

Plectofrondicularia searsi Cushman, Stewart, and Stewart, 1947*d*, p. 78, pl. 10, fig. 5, *a*, *b*; 1949, p. 132, pl. 15, fig. 5; Mallory, 1959, p. 214, pl. 17, fig. 17.

Hypotype 43945, Loc. B-2252.

This species seems to grade into *Plectofrondicularia packardi packardi* Cushman and Schenck and *P. packardi* var. *multilineata* Cushman and Simonson toward the middle of the San Lorenzo formation, and may be ancestral to these species.

Plectofrondicularia trinitatensis Cushman and Jarvis
(Pl. 13, fig. 11)

Plectofrondicularia trinitatensis Cushman and Jarvis, 1929, p. 11, pl. 2, fig. 16; Cushman, 1935*a*, p. 34, pl. 12, fig. 10.

Hypotype 43946, Loc. B-2228.

A few specimens were found in the Butano formation.

Plectofrondicularia vaughani Cushman
(Pl. 12, fig. 7)

Plectofrondicularia vaughani Cushman, 1927*a*, p. 112, pl. 23, fig. 3; Cushman and Hobson, 1935, p. 59, pl. 9, fig. 1, *a, b;* Wilson, 1954, p. 138, pl. 15, fig. 7; Smith, 1956, p. 94, pl. 11, fig. 14.
Plectofrondicularia garzaensis Cushman and Siegfus. Cushman and Simonson, 1944, p. 197, pl. 31, fig. 19.

Hypotype 43947, Loc. B-2271.

Plectofrondicularia cf. *P. vaughani* Cushman
(Pl. 12, figs. 8, 9)

Plectofrondicularia cf. *P. vaughani* Cushman, 1935*a*, p. 34, pl. 12, figs. 8, 9.

Hypotypes 43948, 43949, Lec. B-2228.

These specimens from the Butano formation all display symmetrically arched sutures with the positions of earlier apertures reflected as terminal and similarly placed, in contrast to the alternating character of the chambers of *Plectofrondicularia vaughani* Cushman with aperture pointing first to one side and then to the other. However, although the Butano specimens are larger than the typical, they otherwise compare closely in being much compressed, with the early chambers coiled about the proloculum, and in lacking ornamentation. They may be ancestral to *P. vaughani,* which is well represented higher in the local sequence.

Plectofrondicularia virginiana Cushman and Cederstrom
(Pl. 12, fig. 5)

Plectofrondicularia virginiana Cushman and Cederstrom, 1949, Ellis and Messina.

Hypotype 43950, Loc. B-2256.

Plectofrondicularia vokesi Cushman, Stewart, and Stewart
(Pl. 13, fig. 10)

Plectofrondicularia vokesi Cushman, Stewart, and Stewart, 1949, p. 132, pl. 15, fig. 4; Mallory, 1959, p. 214, pl. 17, fig. 18.

Hypotype 43951, Loc. B-2241.

Genus *Amphimorphina* Neugeboren, 1850

Amphimorphina ignota Cushman and Siegfus

(Pl. 13, figs. 12, *a*, *b*; 13, *a*, *b*)

Amphimorphina ignota Cushman and Siegfus, 1939, p. 27, pl. 6, figs. 10–13; 1942, p. 410, pl. 16, figs. 31–35; Mallory, 1959, pp. 215–216, pl. 18, fig. 7, pl. 33, fig. 9, *a*, *b*.

Hypotypes 43726, 43727, Loc. B-2228.

Mallory's types for this species are identical with the Butano specimens.

Amphimorphina aff. *A. ignota* Cushman and Siegfus

(Pl. 13, fig. 14)

Hypotype 43728, Loc. B-2228.

The lack of any gradation between these almost smooth-walled specimens and the strongly costate typical species distinguishes this smooth form from *Amphimorphina ignota* Cushman and Siegfus, even though both were collected from the same Butano horizon.

Amphimorphina jenkinsi (Church)

(Pl. 13, fig. 15)

Plectofrondicularia jenkinsi Church, 1931, p. 208, pl. A, figs. 4, 5, 7–9; 1943, p. 182, pl. 67, fig. 47; Mallory, 1959, p. 216, pl. 18, fig. 5.

Hypotype 43729, Loc. B-2231.

This species is represented in abundance at the base of the San Lorenzo formation by very poorly preserved specimens.

Amphimorphina cf. *A. jenkinsi* (Church)

(Pl. 13, fig. 16, *a*, *b*)

Hypotype 43730, Loc. B-2255.

A single broken specimen, though more robust than typical, shows the later stages of the test becoming four-sided in end view.

Genus *Nodogenerina* Cushman, 1927

Nodogenerina adolphina (d'Orbigny)

(Pl. 13, fig. 17, *a*, *b*)

Nodosaria (*Dentalina*) *adolphina* d'Orbigny. Cushman and G. D. Hanna, 1927, p. 213, pl. 13, figs. 8, 9.

Hypotype 43899, Loc. B-2228.

Nodogenerina advena Cushman and Laiming

(Pl. 13, figs. 20, 21)

Nodogenerina advena Cushman and Laiming, 1931, p. 106, pl. 11, fig. 19, *a*, *b*; Cushman and Todd, 1945, p. 38, pl. 6, fig. 5; Smith, 1956, p. 95, pl. 11, fig. 13, *a*, *b*.

Hypotypes 43900, Loc. B-2262; 43901, Loc. B-2263.

A slight roughening of the walls of these specimens in the form of longitudinal lines corresponds to the type description of this species. In addition, a row of small spines can be detected around the base of each chamber on most specimens.

Nodogenerina sanctaecrucis Kleinpell

(Pl. 13, fig. 19, *a, b*)

Nodogenerina sanctaecrucis Kleinpell, 1938, p. 246, pl. 4, fig. 22; Smith, 1956, p. 95, pl. 11, fig. 12, *a, b*.

Nodosaria anomala Reuss. Wilson, 1954, p. 136, pl. 14, fig. 11.

Hypotype 43902, Loc. B-2233.

Nodogenerina wegemanni (Cole)

(Pl. 13, figs. 22, 23)

Nodosaria wegemanni (Cole), 1927, p. 17, pl. 3, fig. 8.

Hypotypes 43903, 43904, Loc. B-2228.

These Butano specimens appear to have *Nodogenerina*-type apertures with short neck and lobed lip, and compare closely with *Nodosaria wegemanni* (Cole), in which the apertural features were not observed.

Nodogenerina sp.

(Pl. 13, fig. 18)

Test elongate, slender, almost straight, sides almost parallel, only slightly tapering; chambers numerous, distinct, very gradually increasing in length as added, slightly inflated toward apertural end; sutures distinct, limbate, slightly depressed; wall smooth; intact apertures not observed.

Hypotype 43905, Loc. B-2228.

A few broken specimens seem best assigned to this genus.

Family Buliminidae

Genus *Buliminella* Cushman, 1911

Buliminella curta Cushman

(Pl. 14, fig. 1, *a, b*)

Buliminella curta Cushman. Kleinpell, 1938, pp. 248, 249, pl. 7, fig. 3, pl. 15, fig. 4, pl. 16, fig. 8.

Hypotype 43763, Loc. B-2270.

Buliminella subfusiformis Cushman

(Pl. 14, figs. 2, *a, b*; 3)

Buliminella subfusiformis Cushman. Kleinpell, 1938, pp. 251, 252, pl. 9, fig. 8, pl. 22, fig. 5.

Hypotypes 43764, 43765, Loc. B-2277.

Genus *Bulimina* d'Orbigny, 1826

Bulimina guayabalensis Cole var. *ampla* Cushman and Parker

(Pl. 14, fig. 4)

Bulimina guayabalensis Cole var. *ampla* Cushman and Parker, 1936, p. 43, pl. 8, fig. 1, *a, b, c*; Mallory, 1959, p. 191.

Bulimina cf. *pyrula* d'Orbigny. Rau, 1951, p. 441, pl. 65, figs. 16, 20.

Hypotype 43752, Loc. B-2251.

Bulimina cf. *B. kugleri* Cushman and Renz
(Pl. 14, fig. 5, *a*, *b*)

Hypotype 43753, Loc. B-2271.

The chamber arrangement of this single specimen compares with that described by Cushman and Renz (1942, p. 9, pl. 2, fig. 9).

Bulimina microcostata Cushman and Parker
(Pl. 14, fig. 6, *a*, *b*)

Bulimina microcostata Cushman and Parker, 1936, p. 39, pl. 7, fig. 2, *a*, *b*.

Hypotypes 43754, 43755, Loc. B-2234; 43756, Loc. B-2242.

Abundant specimens from the lower San Lorenzo are typical of this species.

Bulimina ovata d'Orbigny
(Pl. 14, fig. 7, *a*, *b*)

Bulimina ovata d'Orbigny. Cushman and Parker, 1937, p. 47, pl. 6, figs. 4, 5.

Hypotype 43757, Loc. B-2228.

This species from the Butano formation is quite variable.

Bulimina rinconensis Cushman and Laiming
(Pl. 14, fig. 9, *a*, *b*)

Bulimina cf. *rinconensis* Cushman and Laiming. Cushman and Hobson, 1935, p. 62, pl. 9, fig. 4, *a*, *b*.

Bulimina rinconensis Cushman and Laiming, 1947, p. 112, pl. 26, fig. 15.

Hypotype 43758, Loc. B-2277.

This species was not found here below the Vaqueros sample, although Cushman and Hobson report it from the upper San Lorenzo formation.

Bulimina sculptilis Cushman
(Pl. 14, fig. 8, *a*, *b*)

Bulimina sculptilis Cushman, 1923*a*, p. 23, pl. 3, fig. 3; Cushman and Schenck, 1928, p. 311, pl. 43, fig. 16; Wilson, 1954, p. 139, pl. 15, fig. 12, *a*, *b*; Smith, 1956, pp. 95–96, pl. 12, fig. 9, pl. 13, fig. 4, *a*, *b*.

Hypotypes 43759, 43760, Loc. B-2251.

Bulimina cf. *B. socialis* Bornemann
(Pl. 14, fig. 10, *a*, *b*)

Bulimina cf. *socialis* Bornemann. Cushman and Hobson, 1935, p. 62, pl. 9, fig. 2, *a*, *b*.

Hypotype 43761, Loc. B-2277.

Bulimina cf. *B. stalacta* Cushman and Parker
(Pl. 14, fig. 11, *a*, *b*)

Hypotype 43762, Loc. B-2243.

A few poorly preserved specimens are referred to *Bulimina stalacta* Cushman and Parker (1947, p. 99, pl. 23, fig. 21).

Genus *Globobulimina* Cushman, 1927

Globobulimina cf. *G. pacifica* Cushman
(Pl. 14, fig. 12)

Hypotype 43854, Loc. B-2263.

The fragments of several delicate tests are referred to this species recorded by Cushman and Hobson (1935, p. 62, pl. 9, fig. 3, *a*, *b*) and Kleinpell (1938, p. 260, pl. 8, fig. 7).

Genus *Entosolenia* Ehrenberg, 1848

Entosolenia cf. *E. apiculata* (Reuss)
(Pl. 14, fig. 13, *a*, *b*)

Lagena apiculata Reuss. Plummer, 1926, p. 75, pl. 4, fig. 6; Cushman and Todd, 1946, p. 56, pl. 9, fig. 25.

Entosolenia cf. *E. apiculata* (Reuss). Cushman, 1944, p. 43, pl. 7, fig. 10; 1951, p. 42, pl. 9, fig. 7.

Hypotype 43832, Loc. B-2245.

A few poorly preserved specimens have tests with the widest portion toward the base, tapering gradually to a protruding aperture. The apical spine is somewhat stouter than is typical.

Genus *Virgulina* d'Orbigny, 1826

Virgulina bramlettei Galloway and Morrey
(Pl. 15, figs. 1, *a*, *b*; 2)

Virgulina bramlettei Galloway and Morrey, 1929, p. 37, pl. 5, fig. 14; Cushman and Laiming, 1931, p. 109, pl. 12, fig. 4, *a*, *b*; Cushman, 1937*d*, pp. 19, 20, pl. 3, figs. 6–9.

Hypotypes 44033, Loc. B-2228; 44034, Loc. B-2271.

Virgulina californiensis Cushman
(Pl. 15, figs. 3; 4, *a*, *b*)

Virgulina californiensis Cushman. Kleinpell, 1938, p. 261, pl. 8, fig. 4, pl. 15, fig. 8.

Hypotypes 44035, Loc. B-2233; 44036, Loc. B-2255.

A number of well-preserved specimens from the San Lorenzo formation are typical of this species.

Virgulina dibollensis Cushman and Applin
(Pl. 15, fig. 5, *a*, *b*)

Virgulina dibollensis Cushman and Applin. Bandy, 1949, p. 137, pl. 26, fig. 9, *a*, *b*.

Hypotype 44037, Loc. B-2228.

A single Butano specimen appears to be typical of this species.

Genus *Bolivina* d'Orbigny, 1839

Bolivina gracilis Cushman and Applin
(Pl. 15, fig. 8, *a*, *b*)

Bolivina gracilis Cushman and Applin, 1926, p. 167, pl. 7, figs. 1, 2; Cushman, 1935, p. 37, pl. 14, figs. 8–10; 1937*d*, p. 59, pl. 7, figs. 22, 23; Cushman and Todd, 1945, p. 96, pl. 15, fig. 17.

Hypotype 43745, Loc. B-2236.

A few rare specimens, probably young forms, compare well with the figures and descriptions cited.

Bolivina gracilis Cushman and Applin var. *incisurata* Cushman

(Pl. 15, fig. 7, *a*, *b*)

Bolivina gracilis Cushman and Applin var. *danvillensis* Howe and Wallace (not *B. danvillensis* Howe and Wallace), 1932, p. 57, pl. 11, fig. 7; Cushman, 1937*d*, p. 59, pl. 7, fig. 24; Cushman and Todd, 1945, pp. 96, 97, pl. 15, fig. 18.

Bolivina gracilis Cushman and Applin var. *incisurata* Cushman, 1946*b*, pp. 26, 27, pl. 5, fig. 9.

Hypotype 43746, Loc. B-2229.

Bolivina kleinpelli Beck

(Pl. 15, fig. 6, *a*, *b*)

Bolivina kleinpelli Beck, 1943, p. 606, pl. 107, fig. 39.

Bolivina cf. *kleinpelli* Beck. Cushman, Stewart, and Stewart, 1947*b*, p. 62, pl. 8, fig. 8, *a*, *b*.

Bolivina jacksonensis Cushman and Applin. Wilson, 1954, p. 140, pl. 15, fig. 15, *a*, *b*.

Hypotype 43747, Loc. B-2239.

Bolivina marginata Cushman

(Pl. 15, fig. 9, *a*, *b*)

Bolivina marginata Cushman. Cushman and Laiming, 1931, p. 110, pl. 12, figs. 6–8; Kleinpell, 1938, pp. 275, 276, pl. 9, fig. 2.

Hypotype 43748, Loc. B-2256.

Bolivina pisciformis Galloway and Morrey

(Pl. 15, fig. 10, *a*, *b*)

Bolivina pisciformis Galloway and Morrey, 1929, p. 36, pl. 5, fig. 10.

Bolivina sp. (?) Cushman and Hobson, 1935, p. 62, pl. 9, fig. 5, *a*, *b*.

Bolivina aff. *B. alazanensis* Cushman. Smith, 1956, p. 96, pl. 13, fig. 8, *a*, *b*.

Hypotypes 43749, 43750, Loc. B-2263.

Genus *Bifarina* Parker and Jones, 1872

Bifarina eleganta (Plummer)

(Pl. 15, fig. 11, *a*, *b*)

Siphogenerina eleganta Plummer, 1926, p. 126, pl. 8, fig. 1, *a*, *b*, *c*.

Bifarina eleganta (Plummer). Mallory, 1959, p. 204, pl. 17, fig. 2.

Hypotype 43744, Loc. B-2228.

This distinctive form from the Butano formation and Mallory's types for this species are the same.

Genus *Uvigerinella* Cushman, 1926

Uvigerinella obesa Cushman var. *impolita* Cushman and Laiming

(Pl. 16, fig. 10, *a*, *b*)

Uvigerinella obesa impolita Cushman and Laiming, 1931, p. 111, pl. 12, fig. 11, *a*, *b*; Cushman and Hobson, 1935, p. 62, pl. 9, fig. 6, *a*, *b*.

Hypotype 44025, Loc. B-2268.

Genus *Uvigerina* d'Orbigny, 1826

Uvigerina atwilli Cushman and Simonson

(Pl. 16, figs. 5; 6, *a, b;* 7)

Uvigerina atwilli Cushman and Simonson, 1944, p. 200, pl. 33, figs. 2–4.

Hypotypes 44015, 44016, 44017, Loc. B-2256.

Uvigerina auberiana d'Orbigny

(Pl. 16, fig. 1, *a, b*)

Uvigerina auberiana d'Orbigny. Cushman, 1929, p. 95, pl. 13, fig. 36; Kleinpell, 1938, p. 293, pl. 5, fig. 11.

Hypotypes 44018, 44019, Loc. B-2277.

This species was not found here below the base of the Vaqueros formation.

Uvigerina gallowayi Cushman

(Pl. 16, fig. 9, *a, b*)

Uvigerina gallowayi Cushman, 1929, pp. 94, 95, pl. 13, figs. 33, 34; Kleinpell, 1938, p. 294, pl. 5, figs. 1, 2, 5.

Hypotype 44020, Loc. B-2277.

Uvigerina garzaensis Cushman and Siegfus

(Pl. 16, figs. 2; 3, *a, b*)

Uvigerina garzaensis Cushman and Siegfus, 1939, p. 28, pl. 6, fig. 15, *a, b;* Cushman and Siegfus, 1942, p. 414, pl. 17, fig. 5, *a, b;* Smith, 1956, p. 97, pl. 13, fig. 2, *a, b;* Mallory, 1959, p. 208, pl. 37, fig. 2, *a, b*.

Hypotypes 44021, 44022, Loc. B-2228.

Uvigerina garzaensis Cushman and Siegfus var. *nudo-robusta* Mallory

(Pl. 16, fig. 4, *a, b*)

Uvigerina garzaensis Cushman and Siegfus var. *nudo-robusta* Mallory, 1959, p. 208, pl. 17, figs. 11, *a, b,* 13, *a, b*.

Hypotypes 44023, 44024, Loc. B-2251.

Genus *Hopkinsina* Howe and Wallace, 1933

Hopkinsina compressa (Cushman)

(Pl. 16, fig. 8, *a, b*)

Uvigerina compressa Cushman, 1925*c*, p. 10, pl. 4, fig. 2, *a, b, c*.

Hypotype 43873, Loc. B-2277.

A single well-preserved specimen from the Vaqueros formation compares favorably with Cushman's figures and description of this species.

Genus *Siphogenerina* Schlumberger, 1883

Siphogenerina cf. *S. smithi* Kleinpell

(Pl. 16, figs. 11; 12, *a, b*)

Hypotypes 44003, Loc. B-2268; 44004, Loc. B-2277.

A few broken specimens from the upper San Lorenzo and Vaqueros formations are referred to this species.

Genus *Angulogerina* Cushman, 1927

Angulogerina occidentalis Cushman

(Pl. 15, fig. 15, *a, b*)

Angulogerina occidentalis Cushman. Cushman and Laiming, 1931, p. 112, pl. 12, figs. 15, *a, b,* 16.

Hypotype 43731, Loc. B-2271.

Angulogerina cf. *A. wilcoxensis* (Cushman and Ponton)

(Pl. 15, fig. 14, *a, b*)

Hypotypes 43732, 43733, Loc. B-2234.

A few specimens from the lower San Lorenzo formation compare well with Mallory's types (1959, p. 211, pl. 37, fig. 6, *a, b, c*), but neither have more than a suggestion of double ribs running along the angles, as mentioned in the original description.

Angulogerina sp.

(Pl. 15, figs. 12; 13, *a, b*)

Test triserial, triangular in early portion, later chambers more loosely arranged; entire test covered by about 7 continuous plate-like costae destroying somewhat triangular appearance, especially in adult portion of test; wall finely perforate; aperture round, terminal with a short neck.

Hypotypes 43734, 43735, Loc. B-2277.

Only a few specimens were found in the Vaqueros material, making study of this form insufficient to warrant a specific designation.

Family Ellipsoidinidae

Genus *Ellipsonodosaria* A. Silvestri, 1900

Ellipsonodosaria cf. *E. alexanderi* Cushman

(Pl. 21, fig. 1)

Hypotype 43820, Loc. B-2228.

A number of specimens from the Butano formation are referred to *Ellipsonodosaria alexanderi* Cushman (1951, p. 47, pl. 13, fig. 12). The hypotypes of *Nodosaria* sp. *B.* Cook (1950, p. 51), and specimens of this species included on Cook's Assemblage Slide A-5362–40, are also the same.

Ellipsonodosaria atlantisae Cushman

(Pl. 21, fig. 2)

Ellipsonodosaria atlantisae Cushman, 1939*a*, p. 70, pl. 12, figs. 3, 4.
Ellipsonodosaria atlantisae Cushman var. *hispidula* Cushman. Mallory, 1959, p. 221, pl. 19, fig. 2.

Test elongate and straight; chambers as many as 5 on incomplete specimens, inflated, somewhat pyraform, increasing rapidly in size and more rapidly in height than width; constrictions between chambers, sutures not clear; wall finely hispid, with initial end rounded; aperture not observed.

Hypotype 43821, Loc. B-2228.

A few specimens from the Butano formation have been compared to Cushman's illustrations of this species and appear to be the same, as does Mallory's type for the variety, which is figured by Cushman as being much more hispid.

Ellipsonodosaria (?) cf. *E. jarvisi* Cushman
(Pl. 21, fig. 7, *a*, *b*)

Test elongate, rapidly increasing in diameter from subacute initial end to greatest width at apertural end, slightly arcuate; chambers distinct, becoming inflated and subspherical in adult portion of test; sutures distinct, becoming more and more depressed toward apertural end; wall smooth; aperture not observed.

Hypotypes 43822, 43823, Loc. B-2231.

These abundant but poorly preserved specimens from just above the Butano–San Lorenzo contact closely resemble the illustrations of *Ellipsonodosaria ? jarvisi* Cushman (1946*a*, p. 136, pl. 24, fig. 28, pl. 56, figs. 27–29).

Ellipsonodosaria cf. *E. nuttalli* Cushman and Jarvis
(Pl. 21, fig. 5)

Hypotype 43824, Loc. B-2271.

A few broken specimens with smooth walls except for basal spines are referred to *Ellipsonodosaria nuttalli* Cushman and Jarvis (1934, p. 71, pl. 10, fig. 6, *a*, *b*).

Ellipsonodosaria recta Palmer and Bermudez
(Pl. 21, fig. 6, *a*, *b*)

Ellipsonodosaria recta Palmer and Bermudez. Kleinpell, 1938, p. 306, pl. 4, figs. 14, 20.

Hypotype 43825, Loc. B-2263.

This common species from the upper San Lorenzo formation strongly resembles the illustrations of *Ellipsonodosaria cocoaensis* Cushman (1939, pp. 68, 69, pl. 11, figs. 27–33), and Beck (1943, p. 608, pl. 108, fig. 10). *Nodogenerina lepidula* Schwager (Mallory, 1959, p. 217, pl. 18, fig. 10) is also probably the same.

Ellipsonodosaria spinulosa (Montagu)
(Pl. 21, figs. 3, 4)

Nodosaria spinulosa Montagu. Plummer, 1926, p. 89, pl. 4, fig. 19.
Not *Ellipsonodosaria spinulosa* (Montagu) of Mallory, 1959, p. 223, pl. 19, fig. 8.

Hypotypes 43826, 43827, Loc. B-2228.

"*Ellipsonodosaria* sp. *A*." Cushman and Siegfus
(Pl. 21, figs. 8, 9)

Ellipsonodosaria sp. *A*. Cushman and Siegfus, 1942, p. 417, pl. 17, fig. 17.

Hypotypes 43828, Loc. B-2228; 43829, Loc. B-2241.

A small number of oddly shaped specimens appear to be identical with the cited illustration.

Family ROTALIIDAE

Genus *Valvulineria* Cushman, 1926

Valvulineria tumeyensis Cushman and Simonson

(Pl. 17, figs. 3, *a, b, c;* 4, *a, b;* 5, *a, b;* 6, *a, b, c*)

Valvulineria tumeyensis Cushman and Simonson, 1944, p. 201, pl. 33, figs. 13, 14.
Eponides cf. *pygmea* Hantken. Church, 1931, pl. A, figs. 1–3.

Hypotypes 44026, 44027, Loc. B-2234; 44028, Loc. B-2239; 44029, Loc. B-2245.

These small specimens, abundant in the lower San Lorenzo material, have been compared with topotype material of this species (U.C. Loc. A-4693), and with topotypes of *Eponides* cf. *pygmea* Hantken of Church (Calif. Acad. Sci. 1832 deposited at U.C.), and appear to be conspecific.

Valvulineria tumeyensis Cushman and Simonson var. *conica* n. var.

(Pl. 17, figs. 1, *a, b, c;* 2)

Test small, trochoid, spire very high, consisting of about 3 complete whorls, periphery rounded, ventral side umbilicate; chambers distinct, inflated, especially in last-formed whorl of about 6 chambers, increasing gradually as added; sutures distinct, depressed, especially spiral suture; wall smooth, coarsely perforate; aperture a narrow slit at base of last chamber from near periphery into umbilicus.

Holotype diameter 0.30 mm., height 0.30 mm.
Holotype 44030, Loc. B-2238.
Paratype 44031, Loc. B-2238.
Type locality: Loc. B-2238, San Lorenzo formation.

Present only in assemblages containing *Valvulineria tumeyensis,* these specimens bear a striking similarity to that species in size and wall material. However, they differ in having a high spire, fewer chambers in the final whorl (*V. tumeyensis* seeming to average 8), more inflated chambers, and more depressed sutures.

Valvulineria cf. *V. wilcoxensis* Cushman and Ponton

(Pl. 17, fig. 7, *a, b, c*)

Hypotype 44032, Loc. B-2229.

The Butano specimens seem to be slightly thicker than the typical specimens described by Cushman and Ponton (1932, p. 70, pl. 9, fig. 6, *a, b, c*).

Genus *Gyroidina* d'Orbigny, 1826

Gyroidina condoni (Cushman and Schenck)

(Pl. 18, fig. 2, *a, b, c*)

Gyroidina condoni rotundiformis Cushman and Simonson, 1944, p. 201, pl. 33, fig. 17–19.
Gyroidina condoni (Cushman and Schenck). Wilson, 1954, p. 142, pl. 16, fig. 10, *a, b, c.*

Hypotypes 43859, Loc. B2239; 43860, Loc. B-2265.

Gyroidina orbicularis d'Orbigny var. *planata* Cushman

(Pl. 18, fig. 1, *a, b, c*)

Gyroidina soldanii d'Orbigny. Cushman and Parker, 1931, p. 11, pl. 2, fig. 9, *a, b;* Barbat and von Estorff, 1933, p. 173, pl. 23, fig. 6, *a, b;* Cushman and Hobson, 1935, p. 62, pl. 9, fig. 7, *a, b, c;* Smith, 1956, p. 98, pl. 14, fig. 5, *a, b, c.*

Gyroidina orbicularis d'Orbigny var. *planata* Cushman. Mallory, 1959, p. 235, pl. 29, fig. 16, *a, b, c.*

Hypotype 43861, Loc. B-2262.

Gyroidina planulata Cushman and Renz

(Pl. 18, figs. 3, *a, b, c;* 4, *a, b, c*)

Gyroidina planulata Cushman and Renz, 1941, p. 23, pl. 4, fig. 1, *a, b, c.*

Gyroidina cf. *planulata* Cushman and Renz. Cushman, Stewart, and Stewart, 1947*a*, p. 102, pl. 12, fig. 15, *a, b, c.*

Hypotypes 43862, 43863, Loc. B-2265.

Genus *Eponides* Montfort, 1808

Eponides keenani Cushman and Kleinpell

(Pl. 18, fig. 5, *a, b, c*)

Eponides keenani Cushman and Kleinpell, 1934, p. 14, pl. 3, figs. 10, 11.

Eponides duprei Cushman and Schenck. Smith, 1956, p. 98, pl. 15, fig. 1, *a, b, c.*

Hypotype 43833, Loc. B-2277.

Several well-preserved specimens were found in the Vaqueros material.

Eponides kleinpelli Cushman and Frizzell

(Pl. 19, figs. 1, *a, b, c;* 2, *a, b, c*)

Eponides kleinpelli Cushman and Frizzell, 1940, p. 42, pl. 8, fig. 11, *a, b, c;* Rau, 1948, p. 172, pl. 31, figs. 6–8; 1951, p. 447, pl. 66, figs. 12, 13.

Hypotypes 43834, 43835, Loc. B-2275.

Eponides lodoensis Martin var. *martini* Smith

(Pl. 18, fig. 6, *a, b, c*)

Eponides lodoensis var. *martini* Smith, 1957, p. 182, pl. 27, figs. 9, *a, b, c,* 11, *a, b, c.*

Hypotype 43836, Loc. B-2228.

A few specimens were found in the Butano formation.

Eponides cf. *E. mexicana* Cushman

(Pl. 20, fig. 1, *a, b, c*)

Hypotype 43837, Loc. B-2253.

A single specimen appears to be referable to this species as figured by Cushman and M. A. Hanna (1927, p. 54, pl. 5, figs. 8, 9).

Eponides umbonatus (Reuss)

(Pl. 18, figs. 7, *a, b, c;* 8, *a, b, c*)

Eponides umbonata Reuss. Cushman, 1929, p. 98, pl. 14, fig. 8, *a, b, c;* 1935*a*, p. 48, pl. 19, fig. 10, *a, b, c;* 1936*b*, p. 424, pl. 3, fig. 4, *a, b, c;* Mallory, 1959, p. 239, pl. 30, fig. 3, *a, b, c,* pl. 37, fig. 11, *a, b, c;* Smith, 1957, pp. 183–184, pl. 27, figs. 12, *a, b, c,* 14, *a, b, c.*

Eponides umbonatus Reuss. Kleinpell, 1938, p. 322, pl. 6, figs. 9, 12; Cushman, Stewart, and Stewart, 1947*e*, p. 21, pl. 3, figs. 2, 3; Smith, 1956, p. 98, pl. 15, fig. 2, *a, b, c*.

Hypotypes 43838, Loc. B-2228; 43839, Loc. B-2277.

The ventral sutures of the Butano specimens vary from sigmoid to almost straight, as seems to be typical of this species.

Genus *Epistomina* Terquem, 1883

Epistomina eocenica Cushman and M. A. Hanna

(Pl. 20, fig. 2, *a, b, c*)

Epistomina eocenica Cushman and M. A. Hanna, 1927, pp. 53, 54, pl. 5, figs. 4, 5.

Hypotype 43840, Loc. B-2228.

A few poorly preserved Butano specimens seem to represent this species.

Epistomina ramonensis Cushman and Kleinpell

(Pl. 19, fig. 3, *a, b, c*)

Epistomina ramonensis Cushman and Kleinpell, 1934, p. 15, pl. 3, fig. 1, *a, b, c*.

Hypotype 43841, Loc. B-2263.

Genus *Cancris* Montfort, 1808

Cancris mexicanus Cushman and Todd

(Pl. 20, fig. 4, *a, b, c*)

Cancris sagra Nuttall (not d'Orbigny), 1932, p. 27, pl. 6, figs. 6, 7.
Cancris mexicanus Cushman and Todd, 1942*b*, pp. 93, 94, pl. 24, figs. 8–11.

Hypotype 43766, Loc. B-2229.

Family AMPHISTEGINIDAE

Genus *Asterigerina* d'Orbigny, 1839

Asterigerina crassaformis Cushman and Siegfus

(Pl. 20, fig. 3, *a, b, c*)

Asterigerina crassaformis Cushman and Siegfus, 1935, p. 94, pl. 14, fig. 10, *a, b, c;* 1942, p. 420, pl. 18, fig. 1, *a, b, c;* Cushman and Stone, 1949*a*, p. 82, pl. 14, fig. 16; Smith, 1957, pp. 186–187, pl. 28, figs. 7, *a, b, c*, 10, *a, b, c;* Mallory, 1959, p. 242, pl. 37, fig. 13, *a, b, c*.

Hypotype 43740, Loc. B-2228.

A few small specimens from the Butano formation compare well with Smith's and Mallory's types for this species.

Family CASSIDULINIDAE

Genus *Cassidulina* d'Orbigny, 1826

Cassidulina crassipunctata Cushman and Hobson

(Pl. 20, fig. 6, *a, b*)

Cassidulina crassipunctata Cushman and Hobson, 1935, p. 63, pl. 9, fig. 10.

Hypotype 43767, Loc. B-2263.

These sharp-keeled specimens have been favorably compared with topotype material from Cushman and Hobson L.S.J.U. localities 1103, 1102, and 989 (U.C. Locs. A-4901, A-4902, A-4903).

Cassidulina cf. *C. diversa* Cushman and Stone

(Pl. 20, fig. 7, *a, b*)

Hypotypes 43768, 43769, Loc. B-2233.

A number of specimens from the Butano and San Lorenzo formations compare well with the description of this small species by Cushman and Stone (1949*b*, p. 56), but seem to differ in having a broadly rounded periphery.

Cassidulina globosa Hantken

(Pl. 20, fig. 5, *a, b*)

Cassidulina globosa Hantken. Cushman, 1927*a*, p. 167, pl. 26, fig. 13; 1935*a*, p. 49, pl. 20, fig. 12, *a, b;* Cushman and Siegfus, 1942, p. 421, pl. 18, fig. 3, *a, b*.

Hypotype 43770, Loc. B-2262.

The San Lorenzo specimens show some variation in rotundity, with the sutures becoming slightly depressed as the degree of rotundity increases.

Genus *Stichocassidulina* Stone, 1946

Stichocassidulina cf. *S. thalmanni* Stone

(Pl. 20, fig. 8, *a, b*)

Stichocassidulina cf. *S. thalmanni* Stone. Mallory, 1959, p. 226, pl. 19, fig. 9, *a, b, c*.

Hypotype 44010, Loc. B-2233.

A few subglobular specimens from the lower San Lorenzo formation have the large loop-shaped, elongate aperture in the face of the last-formed chamber, and the smaller supplementary apertures situated along the sutures, typical of this species.

Genus *Cassidulinoides* Cushman, 1927

Cassidulinoides californiensis Bramlette

(Pl. 20, fig. 9, *a, b*)

Cassidulinoides californiensis Bramlette. Woodring and Bramlette, 1950, p. 61, pl. 22, fig. 7.

Hypotypes 43771, 43772, Loc. B-2257.

This small species was found at only one locality in the San Lorenzo formation, and there in abundance.

Family Chilostomellidae

Genus *Chilostomella* Reuss, 1850

Chilostomella hadleyi Keijzer

(Pl. 21, fig. 10)

Chilostomella hadleyi Keijzer. Cushman and Todd, 1949, p. 88, pl. 15, figs. 12–14.

Hypotypes 43773, Loc. B-2228; 43774, Loc. B-2233.

A few specimens from the Butano and lower San Lorenzo formation are referred to this species.

Genus *Chilostomelloides* Cushman, 1926

Chilostomelloides ovicula Nuttall

(Pl. 21, fig. 11, *a, b*)

Chilostomelloides ovicula Nuttall. Cushman and Todd, 1949, p. 95, pl. 16, figs. 15, 16.

Hypotype 43775, Loc. B-2228.

The semicircular aperture with distinct lip, situated one-fourth of the way down one side of the test, and not standing out beyond the point of maximum thickness, tends to characterize this species.

Chilostomelloides oviformis (Sherborn and Chapman)

(Pl. 21, fig. 12, *a, b*)

Chilostomelloides oviformis (Sherborn and Chapman). Cushman and Todd, 1949, pp. 94, 95, pl. 16, figs. 7–9.

Hypotype 43776, Loc. B-2228.

Genus *Pullenia* Parker and Jones, 1862

Pullenia eocenica Cushman and Siegfus

(Pl. 21, fig. 13, *a, b*)

Pullenia eocenica Cushman and Siegfus, 1939, p. 31, pl. 7, fig. 1, *a, b;* 1942, p. 420, pl. 18, fig. 2, *a, b;* Mallory, 1959, p. 246, pl. 30, fig. 4, *a, b*.

Hypotype 43957, Loc. B-2228.

Pullenia quinqueloba (Reuss) var. *angusta* Cushman and Todd

(Pl. 21, fig. 14, *a, b*)

Pullenia quinqueloba Plummer (not Reuss), 1926, p. 136, pl. 8, fig. 12; Cole, 1927, p. 32, pl. 5, fig. 15; Cushman, 1939*a*, p. 73, pl. 12, fig. 17; 1940, p. 72, pl. 12, figs. 13, 14; Toulmin, 1941, p. 607, pl. 81, fig. 24; Cushman and Todd, 1942, p. 42, pl. 7, fig. 15.
Pullenia quinqueloba (Reuss) var. *angusta* Cushman and Todd, 1943, p. 10, pl. 2, figs. 3, 4.

Hypotype 43958, Loc. B-2228.

Genus *Sphaeroidina* d'Orbigny, 1826

Sphaeroidina gredalensis Cook MS

(Pl. 21, fig. 15, *a, b*)

Sphaeroidina gredalensis Cook MS. Mallory, 1959, p. 248, pl. 22, fig. 10, *a, b*, pl. 34, fig. 4, *a, b*.

Hypotype 44005, Loc. B-2228.

These specimens compare well with both Mallory's and Cook's (1950, p. 90, pl. 3, fig. 4, *a, b*) types.

Family GLOBIGERINIDAE

Genus *Globigerina* d'Orbigny, 1826

Globigerina decepta Martin

(Pl. 22, fig. 3, *a, b, c*)

Globigerina decepta Martin, 1943, p. 24, pl. 7, fig. 2, *a, b, c;* Smith, 1957, p. 188, pl. 28, fig. 14, *a, b, c;* Mallory, 1959, p. 249, pl. 34, fig. 5, *a, b, c*, pl. 38, fig. 2, *a, b, c*.

Hypotype 43846, Loc. B-2228.

Globigerina ouachitaensis Howe and Wallace

(Pl. 22, figs. 1, *a, b, c*; 2, *a, b, c*)

Globigerina ouachitaensis Howe and Wallace, 1932, p. 74, pl. 10, fig. 7.

Hypotypes 43847, 43848, Loc. B-2228.

Globigerina triloculinoides Plummer

(Pl. 22, figs. 4, *a, b, c*; 5, *a, b*; 6, *a, b*)

Globigerina triloculinoides Plummer, 1926, p. 134, pl. 8, fig. 10, *a, b, c*; Cushman, 1940, p. 72, pl. 12, fig. 15, *a, b*; Toulmin, 1941, p. 607, pl. 82, fig. 3; Beck, 1943, p. 609, pl. 108, figs. 2, 3.

Hypotypes 43849, Loc. B-2228; 43850, Loc. B-2233; 43851, Loc. B-2234.

Genus *Globigerinella* Cushman, 1927

Globigerinella micra (Cole)

(Pl. 22, figs. 7, *a, b*; 8, *a, b*)

Nonion micrus Cole, 1927, p. 22, pl. 5, fig. 12; Weinzierl and Applin, 1929, pp. 400–401, pl. 43, fig. 6, *a, b, c*; Cushman, 1935*a*, p. 30, pl. 11, figs. 14, 15.

Nonion micrum Cole. Cushman, 1939*b*, p. 5, pl. 1, figs. 20–22; Mallory, 1959, p. 181, pl. 15, fig. 3, *a, b, c*, pl. 28, fig. 12, *a, b*.

Globigerinella micra (Cole). Glaessner, 1937, p. 30, pl. 1, fig. 4, *a, b*.

Hypotypes 43852, 43853, Loc. B-2235.

This species is abundantly represented from a few horizons in the lower San Lorenzo formation which are predominantly planktonic in nature.

Genus *Orbulina* d'Orbigny, 1839

Orbulina universa d'Orbigny

(Pl. 22, fig. 9, *a, b*)

Orbulina universa d'Orbigny. Beck, 1943, p. 609, pl. 108, fig. 25.

Hypotype 43917, Loc. B-2251.

Family HANTKENINIDAE

Genus *Hantkenina* Cushman, 1924

Hantkenina alabamensis Cushman

(Pl. 22, fig. 11)

Hantkenina alabamensis Cushman, 1927*b*, p. 160, pl. 25, fig. 17; 1935*a*, p. 49, pl. 13, figs. 1–5; Coryell and Embich, 1937, p. 299, pl. 43, fig. 10; Mallory, 1959, pp. 251–252.

Hypotype 43864, Loc. B-2228.

Hantkenina dumblei Weinzierl and Applin

(Pl. 22, fig. 10, *a, b*)

Hantkenina dumblei Weinzierl and Applin, 1929, p. 402, pl. 43, fig. 5, *a, b*.

Hypotype 43865, Loc. B-2234.

A few specimens from the San Lorenzo formation have slightly lobulate chambers rapidly increasing in size and becoming elongate, typical of this species.

Family GLOBOROTALIIDAE

Genus *Globorotalia* Cushman, 1927

Globorotalia crassata (Cushman) var. *aequa* Cushman and Renz

(Pl. 22, fig. 12, *a, b, c*)

Globorotalia crassata (Cushman) var. *aequa* Cushman and Renz, 1942, p. 12, pl. 3, fig. 3, *a, b;* Cushman and Todd, 1942, p. 44, pl. 8, figs. 7–9; Cushman and Bermudez, 1949, p. 37, pl. 7, figs. 7–9.

Hypotypes 43855, 43856, Loc. B-2228.

Family ANOMALINIDAE

Genus *Anomalina* d'Orbigny, 1826

Anomalina californiensis Cushman and Hobson

(Pl. 23, fig. 6, *a, b, c*)

Anomalina californiensis Cushman and Hobson, 1935, p. 64, pl. 9, fig. 8, *a, b, c;* Smith, 1956, p. 100, pl. 16, fig. 3, *a, b, c.*

Hypotypes 43736, Loc. B-2263; 43737, Loc. B-2277.

These common San Lorenzo specimens are conspecific with topotype material from Cushman and Hobson L.S.J.U. localities 1103, 1102, and 989 (U.C. Locs. A-4901, A-4902, A-4903).

Anomalina garzaensis Cushman and Siegfus

(Pl. 23, fig. 5, *a, b, c*)

Anomalina garzaensis Cushman and Siegfus, 1939, p. 32, pl. 7, fig. 3, *a, b, c;* 1942, p. 422, pl. 18, fig. 6, *a, b, c.*

Hypotype 43738, Loc. B-2228.

Genus *Anomalinoides* Brotzen, 1942

Anomalinoides cf. *A. globosa* Brotzen

(Pl. 23, fig. 4, *a, b, c*)

Hypotype 43739, Loc. B-2228.

A single Butano specimen is referred to this species.

Genus *Planulina* d'Orbigny, 1826

Planulina haydoni Cushman and Schenck

(Pl. 23, figs. 1, *a, b, c;* 2; 3)

Planulina haydoni Cushman and Schenck, 1928, p. 316, pl. 45, fig. 7, *a, b, c;* Wilson, 1954, p. 144, pl. 17, fig. 3, *a, b, c;* Smith, 1956, p. 100, pl. 16, fig. 5, *a, b, c.*

Hypotypes 43923, 43924, 43925, Loc. B-2252.

These distinctive specimens from the San Lorenzo formation are conspecific with Cushman and Schenck's holotype for this species (U.C. type 31436).

Genus *Cibicides* Montfort, 1808

Cibicides cushmani Nuttall

(Pl. 23, fig. 7, *a, b, c*)

Cibicides cushmani Nuttall, 1930, p. 291, pl. 25, figs. 3, 5, 6; Cushman and Siegfus, 1939, p. 33, pl. 7, fig. 7, *a, b, c;* 1942, p. 423, pl. 18, fig. 10, *a, b, c;* Smith, 1957, p. 192, pl. 31, fig. 4, *a, b, c;* Mallory, 1959, pp. 264–265, pl. 31, fig. 3, *a, b, c.*

Hypotype 43777, Loc. B-2228.

Cibicides falconensis Renz

(Pl. 23, fig. 9, *a, b, c*)

Cibicides falconensis Renz, 1948, p. 128, pl. 11, figs. 6, *a, b, c,* 7.

Hypotype 43778, Loc. B-2233.

Cibicides hodgei Cushman and Schenck

(Pl. 23, fig. 8, *a, b, c*)

Cibicides hodgei Cushman and Schenck, 1928, p. 315, pl. 45, figs. 3–5; Beck, 1943, p. 611, pl. 109, figs. 24–28; Cushman and Simonson, 1944, p. 202, pl. 34, figs. 14–15; Detling, 1946, p. 359, pl. 51, figs. 6, 8; Smith, 1956, p. 101, pl. 16, fig. 1, *a, b, c;* Mallory, 1959, pp. 265–266, pl. 24, fig. 6, *a, b, c.*

Cibicides cf. *hodgei* Cushman and Schenck. Wilson, 1954, p. 144, pl. 17, fig. 5, *a, b, c.*

Hypotypes 43779, 43780, Loc. B-2252.

These San Lorenzo specimens are conspecific with Cushman and Schenck's holotype for this species (U.C. type 31435).

Cibicides pseudoungerianus (Cushman)
var. *evolutus* Cushman and Hobson

(Pl. 23, fig. 10, *a, b, c*)

Cibicides pseudoungerianus (Cushman) *evolutus* Cushman and Hobson, 1935, p. 64, pl. 9, fig. 11, *a, b, c;* Wilson, 1954, p. 144, pl. 17, figs. 7, 8.

Hypotypes 43781, Loc. B-2262; 43782, Loc. B-2277.

Ranging extensively through the San Lorenzo formation, these specimens are conspecific with topotype material from Cushman and Hobson, L.S.J.U. localities 1103, 1102, and 989 (U.C. Locs. A-4901, A-4902, A-4903).

Genus *Cibicidoides* Brotzen, 1936

Cibicidoides cf. *C. midwayensis* (Plummer)

(Pl. 23, fig. 11, *a, b, c*)

Hypotype 43783, Loc. B-2270.

Only a single specimen was found in the upper San Lorenzo material.

DESCRIPTION OF LOCALITIES

All but one of the following localities are on the San Lorenzo River between two and four miles north of Boulder Creek, the exception being on State Highway 9, two miles north of Boulder Creek, Santa Cruz County, California. Locality numbers refer to the collections of the University of California Museum of Paleontology. Ben Lomond Quadrangle (Army Map Service, 1946 ed.) was used.

LOCALITY B-2228

Upper Eocene. Butano formation

On west bank 400 feet downstream from where stream joins the San Lorenzo River from the northwest at 37° 10′ 51″ North latitude, and 122° 08′ 25″ West longitude, and 210 feet upstream from Butano-San Lorenzo contact. Stratigraphically 15 feet above center of Butano anticline and 145 feet below top of Butano formation, at stream level, toward top of a 6-foot gray siltstone member.

LOCALITY B-2229

Upper Eocene. Butano formation

On the west bank 62 feet downstream from locality B-2228. Stratigraphically 115 feet below top of Butano formation, at stream level, in 1-inch black siltstone stringer at top of a 2-foot bed of alternating coarse and fine-grained siltstone.

LOCALITY B-2230

Upper Eocene. Butano formation

On west bank 21 feet downstream from locality B-2229. Stratigraphically 108 feet below top of Butano formation, at stream level, in thin-bedded black siltstone stringer.

LOCALITY B-2231

Upper Eocene. San Lorenzo formation

On east bank 58 feet downstream from Butano–San Lorenzo contact, and 28 feet stratigraphically above the contact, at stream level, in dark gray siltstone.

LOCALITY B-2232

Upper Eocene. San Lorenzo formation

On east bank 131 feet downstream from locality B-2231. Stratigraphically 130 feet above base of San Lorenzo formation, at stream level, in black siltstone.

LOCALITY B-2233

Upper Eocene. San Lorenzo formation

On east bank 89 feet downstream from locality B-2232, and 3 feet upstream from where a small stream joins the San Lorenzo River from the east. Stratigraphically 197 feet above base of San Lorenzo formation, at stream level, in dark gray, well-bedded siltstone.

LOCALITY B-2234

Upper Eocene. San Lorenzo formation

On east bank 83 feet downstream from locality B-2233. Stratigraphically 258 feet above base of San Lorenzo formation, at stream level, in gray to black siltstone.

LOCALITY B-2235

Upper Eocene. San Lorenzo formation

On east bank 65 feet downstream from locality B-2234. Stratigraphically 304 feet above base of San Lorenzo formation, at stream level, in gray siltstone.

Locality B-2236

Upper Eocene. San Lorenzo formation

On south or left bank going downstream, 130 feet downstream from locality B-2235, where course of stream parallels strike of beds. Stratigraphically 354 feet above base of San Lorenzo formation, 2 feet above stream level, in gray to black siltstone.

Locality B-2237

Upper Eocene. San Lorenzo formation

On east bank 50 feet downstream from locality B-2236, at sharp bend where course of stream changes from westward to southeastward. Stratigraphically 370 feet above base of San Lorenzo formation, at stream level, in gray siltstone.

Locality B-2238

Upper Eocene. San Lorenzo formation

On east bank 3 feet downstream from locality B-2237, at stream level, in gray siltstone.

Locality B-2239

Upper Eocene. San Lorenzo formation

On east bank 3 feet downstream from locality B-2238, at stream level, in gray siltstone.

Locality B-2240

Upper Eocene. San Lorenzo formation

On west bank 13 feet downstream from locality B-2239, at stream level, in gray, sandy siltstone.

Locality B-2241

Upper Eocene. San Lorenzo formation

On east bank 177 feet downstream from locality B-2240. Stratigraphically 495 feet above base of San Lorenzo formation, at stream level, in gray to black siltstone.

Locality B-2242

Upper Eocene. San Lorenzo formation

On east bank 17 feet downstream from locality B-2241. Stratigraphically 507 feet above base of San Lorenzo formation, at stream level, in gray siltstone.

Locality B-2243

Upper Eocene. San Lorenzo formation

On west bank 81 feet downstream from locality B-2242. Stratigraphically 557 feet above base of San Lorenzo formation, at stream level, in gray to black, well-bedded siltstone.

Locality B-2244

Upper Eocene. San Lorenzo formation

One-third out into stream from south or right bank going downstream, 56 feet downstream from locality B-2243. Stratigraphically 593 feet above base of San Lorenzo formation, and 5 feet stratigraphically below a 15-foot massive sandstone bed which forms south wall of a 150-foot section of stream paralleling strike. At west end of this 150-foot east-west section, in gray to black, well-bedded siltstone.

Locality B-2245

Upper Eocene. San Lorenzo formation

One-third of way into stream from north or left bank going downstream, 150 feet downstream from locality B-2244, at east end of east-west section. At same stratigraphic horizon as locality B-2244, in gray to black siltstone.

Locality B-2246

Upper Eocene. San Lorenzo formation

On west bank 42 feet downstream from locality B-2245. Stratigraphically 627 feet above base of San Lorenzo formation, and 15 feet stratigraphically above a 15-foot massive sandstone bed, at stream level, in gray, massive siltstone.

Locality B-2247

Upper Eocene. San Lorenzo formation

On west bank 23 feet downstream from locality B-2246. Stratigraphically 643 feet above base of San Lorenzo formation, at stream level, in gray to black siltstone.

Locality B-2248

Upper Eocene. San Lorenzo formation

On west bank 24 feet downstream from locality B-2247. Stratigraphically 662 feet above base of San Lorenzo formation, at stream level, in black, well-bedded siltstone.

Locality B-2249

Upper Eocene. San Lorenzo formation

On east bank 59 feet downstream from locality B-2248. Stratigraphically 708 feet above base of San Lorenzo formation, at stream level, in black thin-bedded siltstone.

Locality B-2250

Upper Eocene. San Lorenzo formation

On east bank 32 feet downstream from locality B-2249. Stratigraphically 732 feet above base of San Lorenzo formation, at stream level, in gray, fine-grained siltstone.

Locality B-2251

Oligocene. San Lorenzo formation

At center of stream 33 feet downstream from locality B-2250. Stratigraphically 757 feet above base of San Lorenzo formation, and 20 feet stratigraphically below a 2-foot limy siltstone bed, in gray, massive siltstone.

LOCALITY B-2252

Oligocene. San Lorenzo formation

At center of stream 78 feet downstream from locality B-2251. Stratigraphically 813 feet above base of San Lorenzo formation, in gray, massive siltstone.

LOCALITY B-2253

Oligocene. San Lorenzo formation

On east bank 59 feet downstream from locality B-2252. Stratigraphically 855 feet above base of San Lorenzo formation, at stream level, in gray, massive siltstone.

LOCALITY B-2254

Oligocene. San Lorenzo formation

On east bank 50 feet downstream from locality B-2253. Stratigraphically 892 feet above base of San Lorenzo formation, at stream level, in gray, coarse-grained siltstone.

LOCALITY B-2255

Oligocene. San Lorenzo formation

In recess of west bank 112 feet downstream from locality B-2254. Stratigraphically 975 feet above base of San Lorenzo formation, and 45 feet stratigraphically below a 4-foot limy siltstone bed, 2 feet above stream level, in gray, massive siltstone.

LOCALITY B-2256

Oligocene. San Lorenzo formation

On west bank 10 feet downstream from locality B-2255, at stream level, in gray, massive siltstone.

LOCALITY B-2257

"Oligo-Miocene." San Lorenzo formation

On west bank 160 feet downstream from locality B-2256. Stratigraphically 1,102 feet above base of San Lorenzo formation, at stream level, in gray, massive siltstone.

LOCALITY B-2258

"Oligo-Miocene." San Lorenzo formation

On west bank 65 feet downstream from locality B-2257. Stratigraphically 1,130 feet above base of San Lorenzo formation, at stream level, in gray, massive siltstone.

LOCALITY B-2259

"Oligo-Miocene." San Lorenzo formation

On west bank 54 feet downstream from locality B-2258, and 6 feet downstream from a cement dam. Stratigraphically 1,154 feet above base of San Lorenzo formation, at stream level, in gray, massive siltstone.

LOCALITY B-2260

"Oligo-Miocene." San Lorenzo formation

On west bank 129 feet downstream from locality B-2259, and beneath center of "old bridge" behind Riverside Grove Swimming Pool, at 37° 10′ 31″ North latitude, 122° 08′ 21″ West longitude, which used to connect resort area with State Highway 9. Stratigraphically 1,211 feet above base of San Lorenzo formation, at stream level, in gray, massive, coarse-grained siltstone.

Locality B-2261

"Oligo-Miocene." San Lorenzo formation

On west bank 66 feet downstream from locality B-2260 and "old bridge." Stratigraphcially 1,240 feet above base of San Lorenzo formation, at stream level, in gray, massive siltstone.

Locality B-2262

"Oligo-Miocene." San Lorenzo formation

On east bank 103 feet downstream from locality B-2261. Stratigraphically 1,308 feet above base of San Lorenzo formation, and 50 feet stratigraphically below a 4-foot nodular siltstone bed, at stream level, in gray, massive, coarse-grained siltstone.

Locality B-2263

"Oligo-Miocene." San Lorenzo formation

On south or right bank going downstream, 353 feet downstream from locality B-2262. Stratigraphically 1,370 feet above base of San Lorenzo formation, at stream level, in gray, massive, coarse-grained siltstone.

Locality B-2264

"Oligo-Miocene." San Lorenzo formation

On east bank across stream from retaining wall made of boulders, 288 feet downstream from locality B-2263, and 275 feet upstream from north side of main bridge at 37° 10′ 22″ North latitude, 122° 08′ 17″ West longitude, which connects Riverside Grove with State Highway 9. Stratigraphically 1,408 feet above base of San Lorenzo formation, at stream level, in gray, massive, coarse-grained siltstone.

Locality B-2265

"Oligo-Miocene." San Lorenzo formation

On east bank 75 feet downstream from south side of main bridge into Riverside Grove. Stratigraphically 1,518 feet above base of San Lorenzo formation, at stream level, in gray, massive, coarse-grained siltstone.

Locality B-2266

"Oligo-Miocene." San Lorenzo formation

At center of stream 617 feet downstream from locality B-2265 and 85 feet downstream from west side of bridge at 37° 10′ 21″ North latitude, 122° 08′ 22″ West longitude, which crosses San Lorenzo River within Riverside Grove area. Stratigraphically 1,638 feet above base of San Lorenzo formation, in gray, massive, coarse-grained siltstone.

Locality B-2267

"Oligo-Miocene." San Lorenzo formation

On west bank at turn in stream 81 feet downstream from locality B-2266. Stratigraphically 1,666 feet above base of San Lorenzo formation, at stream level, in gray, massive, coarse-grained siltstone.

Locality B-2272[1]

"Oligo-Miocene." San Lorenzo formation

At middle of stream 623 feet downstream from locality B-2267, and 150 feet downstream from where stream joins the San Lorenzo River from the west at 37° 10′ 17″ North latitude, 122° 08′ 17″ West longitude. Stratigraphically 1,712 feet above base of San Lorenzo formation, in gray, massive, coarse-grained siltstone.

Locality B-2270

"Oligo-Miocene." San Lorenzo formation

On right bank going downstream, where course of stream is northeast, 427 feet downstream from locality B-2272. Stratigraphically 1,700 feet above base of San Lorenzo formation, at stream level, in gray, massive, coarse-grained siltstone.

Locality B-2271

"Oligo-Miocene." San Lorenzo formation

On east bank 550 feet downstream from locality B-2270, and at same stratigraphic horizon. Eight feet above stream level, in gray, massive siltstone.

Locality B-2268

"Oligo-Miocene." San Lorenzo formation

On north or left bank going downstream where course of stream is east, 187 feet downstream from locality B-2271. Stratigraphically 1,692 feet above base of San Lorenzo formation, at stream level, in gray, massive siltstone.

Locality B-2269

"Oligo-Miocene." San Lorenzo formation

On south bank of small stream where it joins San Lorenzo River from east at 37° 10′ 07″ North latitude, 122° 08′ 08″ West longitude, 400 feet downstream from locality B-2268 and at same stratigraphic horizon. At stream level, in gray, massive siltstone.

Locality B-2273

"Oligo-Miocene." San Lorenzo formation

On right bank of Kings Creek going downstream, 170 feet north of where Kings Creek joins San Lorenzo River at 37° 09′ 22″ North latitude, 122° 08′ 02″ West longitude. Stratigraphically 466 feet below top of San Lorenzo formation, 4 feet above stream level, in dark gray, massive siltstone forming vertical wall.

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[1] Localities B-2268 to B-2272 are not listed in numerical order but in the order in which they appear along the course of the winding stream.

LOCALITY B-2274

"Oligo-Miocene." San Lorenzo formation

On east bank 25 feet downstream from where Kings Creek joins San Lorenzo River. Stratigraphically 459 feet below top of San Lorenzo formation, 2 feet above stream level, in dark gray, massive siltstone.

LOCALITY B-2275

"Oligo-Miocene." San Lorenzo formation

On east bank 67 feet downstream from where Kings Creek joins San Lorenzo River. Stratigraphically 443 feet below top of San Lorenzo formation, 3 feet above stream level, in dark gray, massive siltstone.

LOCALITY B-2276

"Oligo-Miocene." San Lorenzo formation

On east bank 785 feet downstream from locality B-2275, and 334 feet upstream from San Lorenzo–Vaqueros contact. Stratigraphically 195 feet below top of San Lorenzo formation, 3 feet above stream level, in dark gray, massive, coarse-grained siltstone.

LOCALITY B-2277

"Oligo-Miocene." Vaqueros formation

In roadcut on southeast side of State Highway 9, at 37° 09′ 07″ North latitude, 122° 08′ 03″ West longitude, 325 feet southwest of San Lorenzo–Vaqueros contact, and 400 feet southwest of "old" Kings Creek Road. Stratigraphically 160 feet above base of Vaqueros formation, 6 feet above road and behind telegraph pole, in prominent 1-foot, dark gray, massive siltstone bed.

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PLATES

PLATE 1

ASTRORIZIDAE, RHIZAMMINIDAE, SACCAMMINIDAE, HYPERAMMINIDAE, REOPHACIDAE, AMMODISCIDAE, LITUOLIDAE

1. *Rhabdammina eocenica* Cushman and G. D. Hanna × 43. U.C. Loc. B-2228.

2. *Bathysiphon eocenica* Cushman and G. D. Hanna × 43. U.C. Loc. B-2228. Hypotype 43741.

3. *Bathysiphon eocenica* Cushman and G. D. Hanna × 51. U.C. Loc. B-2228. Hypotype 43742.

4. *Bathysiphon sanctaecrucis* Cushman and Kleinpell × 43. U.C. Loc. B-2277.

5. *Pelosina complanata* Franke × 71. *a,* side view; *b,* peripheral view. U.C. Loc. B-2238.

6. *Hyperammina elongata* H. B. Brady? × 51. U.C. Loc. B-2238.

7. *Reophax* cf. *R. pilulifer* H. B. Brady × 43. U.C. Loc. B-2267.

8. *Discammina ? eocenica* Mallory × 46. *a,* side view; *b,* peripheral view. U.C. Loc. B-2263.

9. *Haplophragmoides obliquicameratus* Marks × 43. *a,* side view; *b,* peripheral view. U.C. Loc. B-2228. Hypotype 43871.

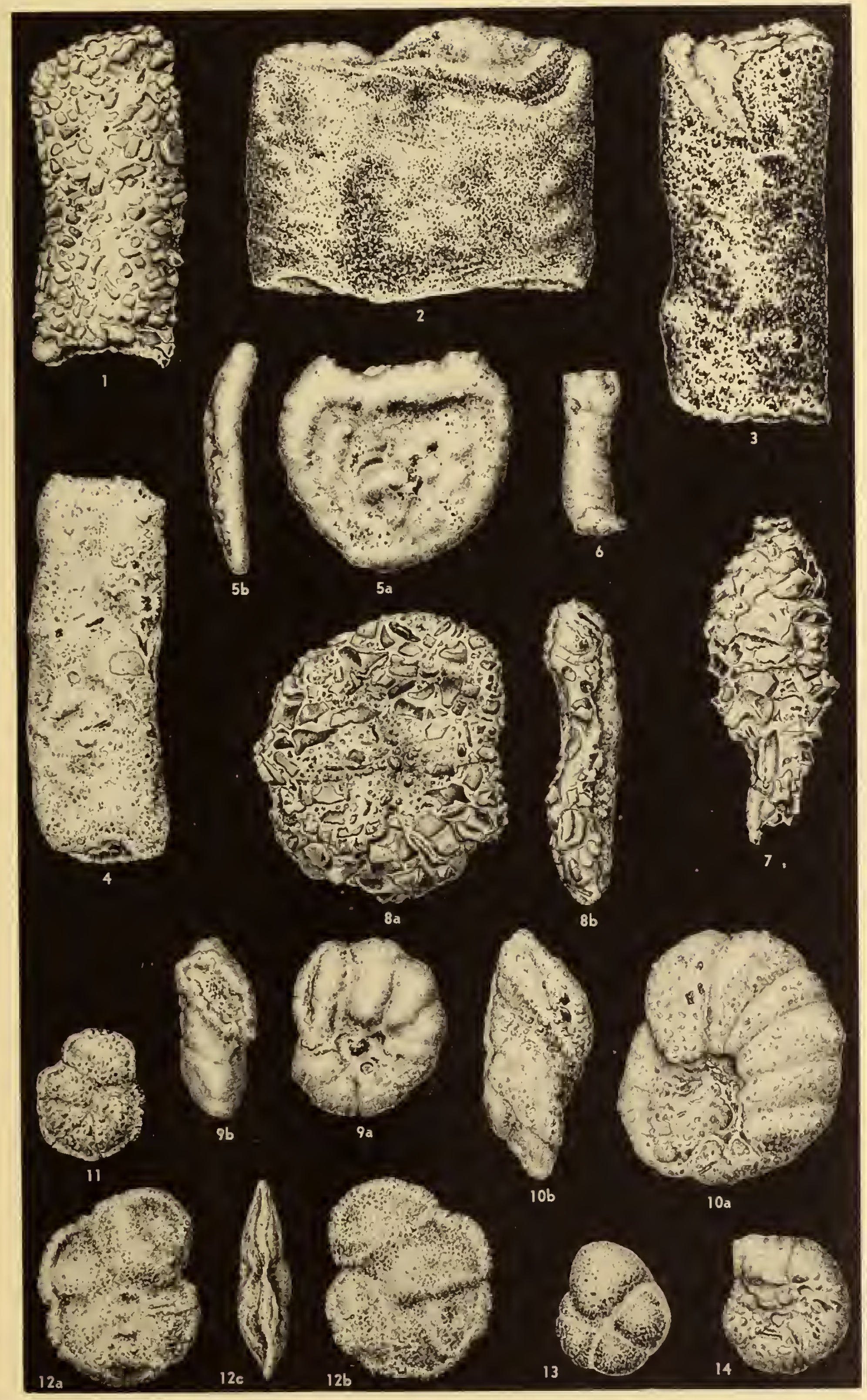
10. *Haplophragmoides obliquicameratus* Marks × 51. *a,* side view; *b,* peripheral view. U.C. Loc. B-2253. Hypotype 43872.

11. *Haplophragmoides deflata* Sullivan n. sp. × 25. U.C. Loc. B-2239. Paratype 43867.

12. *Haplophragmoides deflata* Sullivan n. sp. × 36. *a, b,* opposite sides; *c,* peripheral view. U.C. Loc. B-2243. Holotype 43866.

13. *Haplophragmoides kirki* Wickenden × 43. U.C. Loc. B-2238.

14. *Haplophragmoides flagleri* Cushman and Hedberg var. *trinitatensis* Cushman and Renz × 43. U.C. Loc. B-2228.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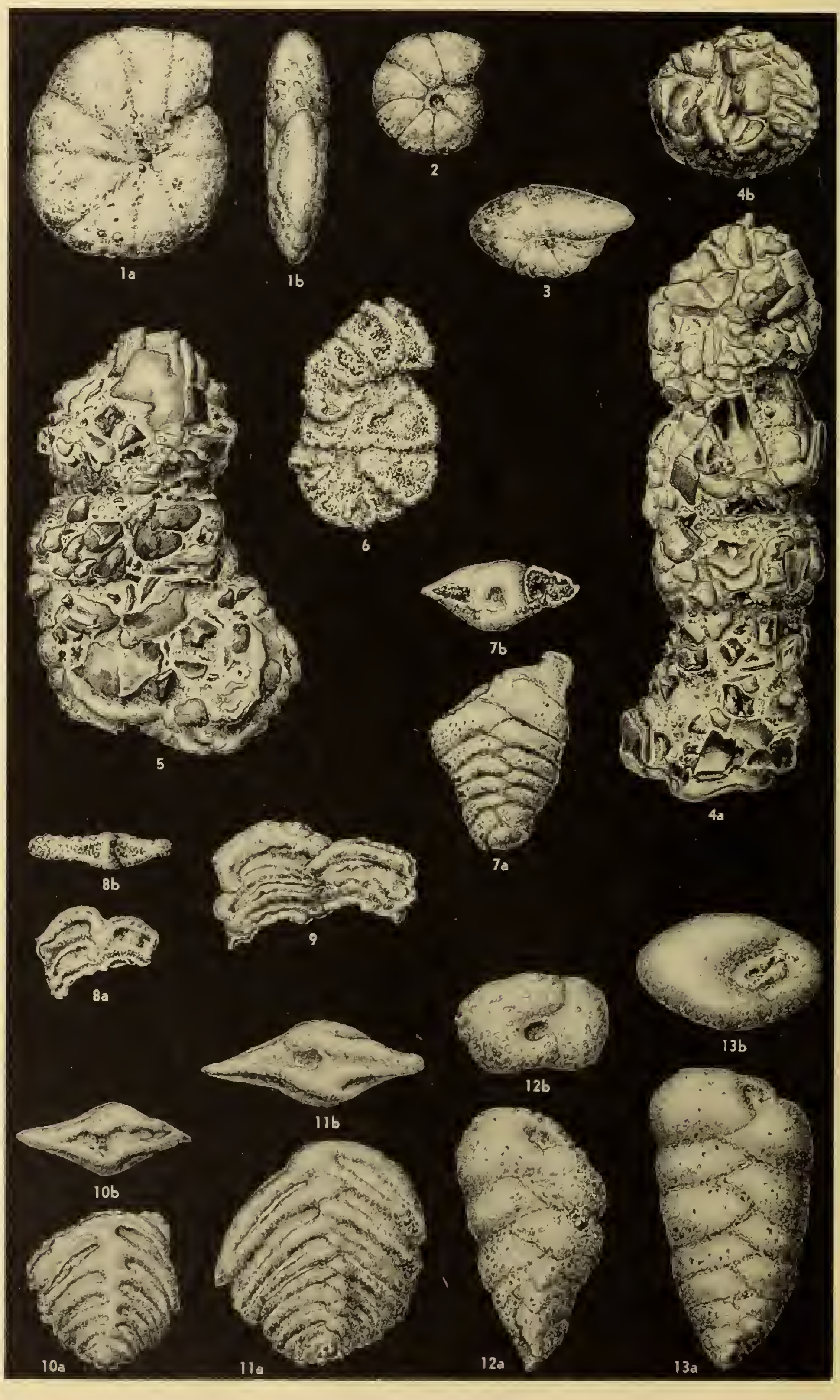
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13a

PLATE 2

LITUOLIDAE, TEXTULARIIDAE, VERNEUILINIDAE

1. *Cyclammina* cf. *C. incisa* Stache × 25. *a,* side view; *b,* peripheral view. U.C. Loc. B-2253.

2. *Cyclammina samanica* W. Berry × 25. U.C. Loc. B-2238. Hypotype 43786.

3. *Cyclammina clarki* (G. D. Hanna) × 25. U.C. Loc. B-2277.

4. *Ammobaculites cubensis* Cushman and Bermudez × 36. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43723.

5. *Ammobaculites cubensis* Cushman and Bermudez × 36. U.C. Loc. B-2228. Hypotype 43724.

6. *Ammobaculites* sp. × 43. U.C. Loc. B-2244.

7. *Spiroplectammina eocenica* (Cushman and Barksdale) × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2238.

8. *Textularia* cf. *T. warreni* Cushman and Ellisor × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2239. Hypotype 44011.

9. *Textularia* cf. *T. warreni* Cushman and Ellisor × 43. U.C. Loc. B-2253. Hypotype 44012.

10. *Vulvulina curta* Cushman and Siegfus × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 44039.

11. *Vulvulina curta* Cushman and Siegfus × 51. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 44038.

12. *Gaudryina laevigata* Franke × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2267.

13. *Gaudryina* sp. × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2275.

PLATE 3

VALVULINIDAE

1. *Eggerella ihungia* Finlay × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2253.

2. *Eggerella* (?) cf. *E. trochoides* (Reuss) × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2244.

3. *Eggerella elongata* Blaisdell MS. × 71. U.C. Loc. B-2244. Hypotype 43812.

4. *Eggerella elongata* Blaisdell MS. × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2244. Hypotype 43813.

5. *Eggerella* sp. × 71. U.C. Loc. B-2238. Hypotype 43818.

6. *Eggerella* sp. × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2238. Hypotype 43819.

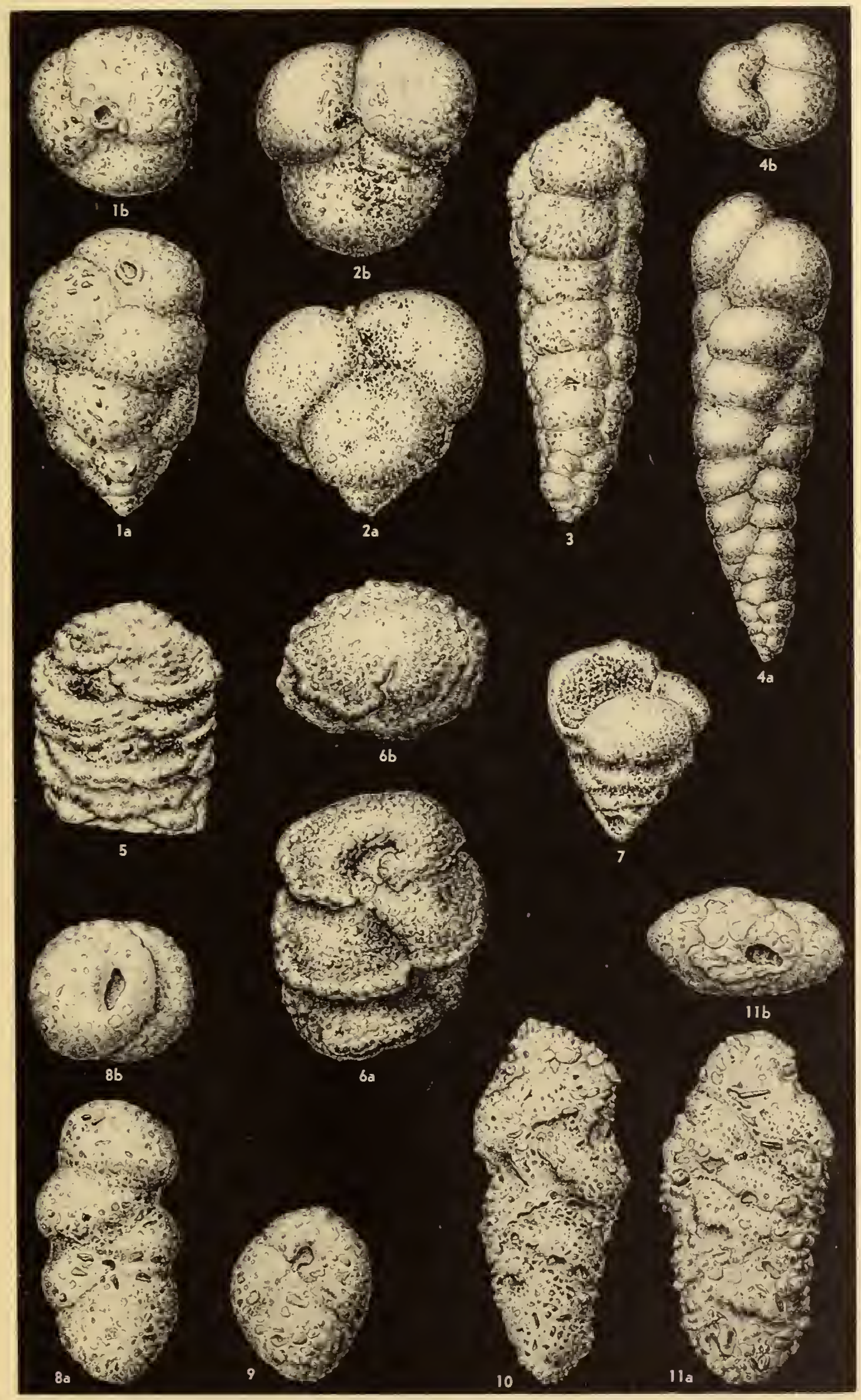
7. *Eggerella subconica* Parr × 71. U.C. Loc. B-2238.

8. *Plectina garzaensis* Cushman and Siegfus × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43926.

9. *Plectina garzaensis* Cushman and Siegfus × 43. U.C. Loc. B-2228. Hypotype 43927.

10. *Plectina* cf. *P. ruthenica* (Reuss) × 43. U.C. Loc. B-2277. Hypotype 43929.

11. *Plectina* cf. *P. ruthenica* (Reuss) × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2266. Hypotype 43928.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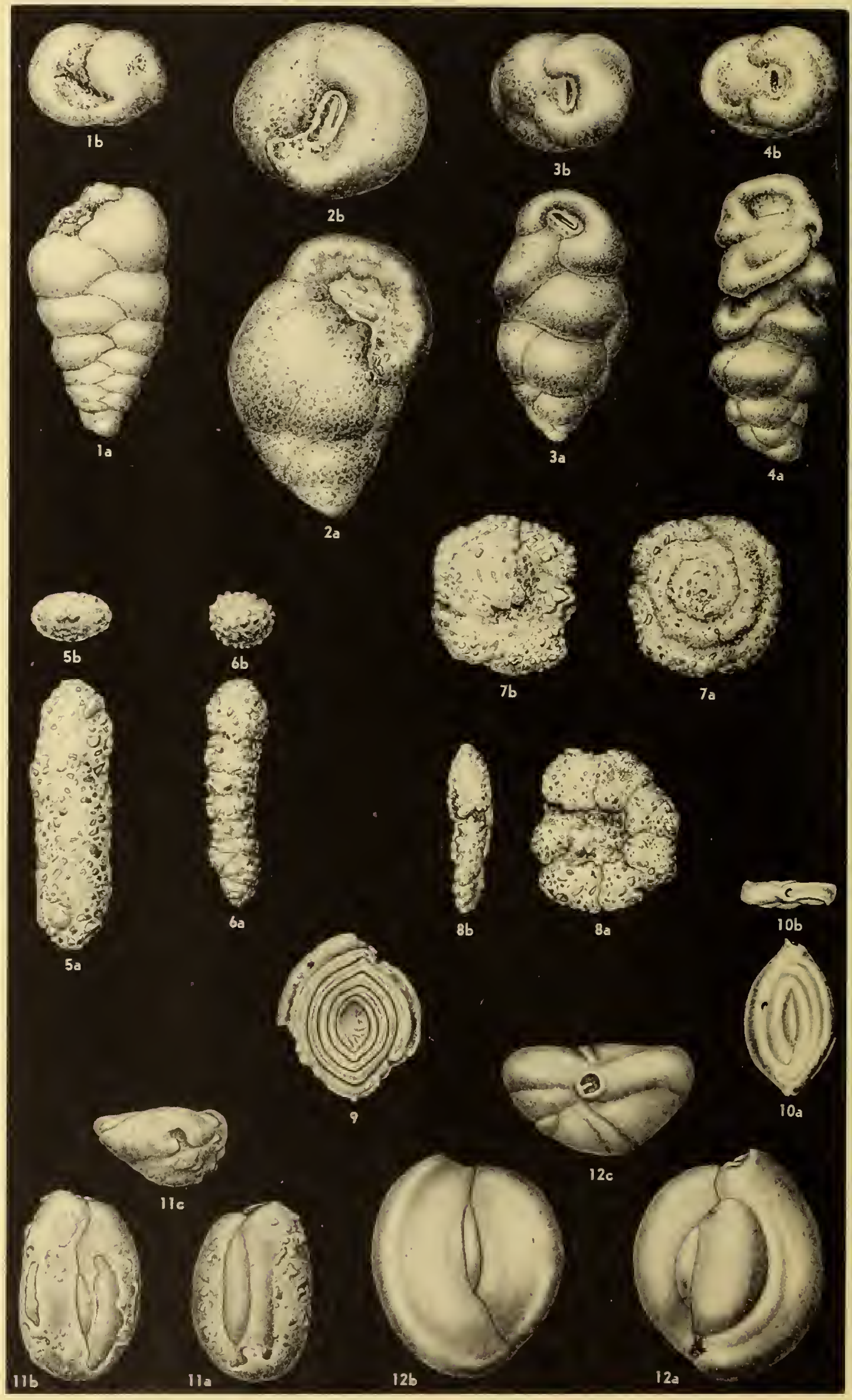
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12b
12a

PLATE 4

VALVULINIDAE, TROCHAMMINIDAE, MILIOLIDAE

1. *Dorothia californica* Cushman and Kleinpell × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

2. *Karreriella barbati* Cushman × 51. *a,* side view; *b,* apertural view. U.C. Loc. B-2273.

3. *Karreriella washingtonensis* Rau × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43877.

4. *Karreriella washingtonensis* Rau × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43878.

5. *Karreriella media-aquaensis* Mallory × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

6. *Martinottiella eocenica* Cushman and Bermudez × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

7. *Trochammina albertensis* Wickenden × 43. *a,* dorsal view; *b,* ventral view. U.C. Loc. B-2240.

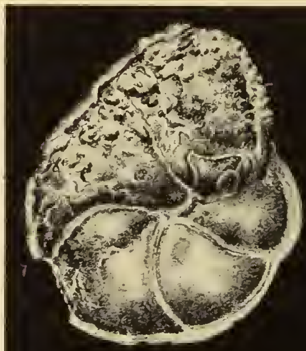
8. *Trochammina diagonis* (Carsey) Cushman and Waters × 43. *a,* dorsal view; *b,* peripheral view. U.C. Loc. B-2237.

9. *Spiroloculina wilcoxensis* Cushman and Garrett × 71. U.C. Loc. B-2239. Hypotype 44007.

10. *Spiroloculina lamposa* Hussey × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

11. *Quinqueloculina minuta* Beck × 71. *a, b,* opposite sides; *c,* apertural view. U.C. Loc. B-2272.

12. *Quinqueloculina triangularis* d'Orbigny × 71. *a, b,* opposite sides; *c,* apertural view. U.C. Loc. B-2271.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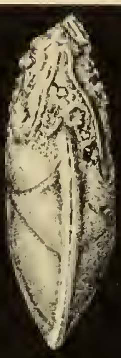
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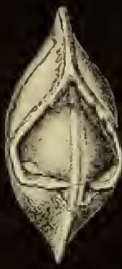
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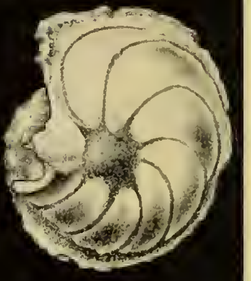
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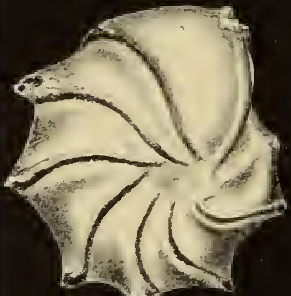
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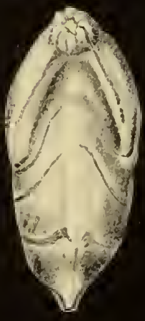
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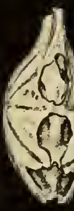
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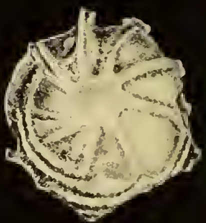
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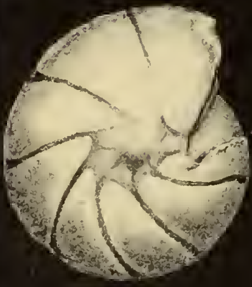
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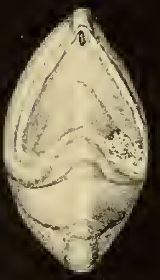
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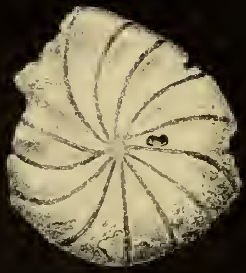
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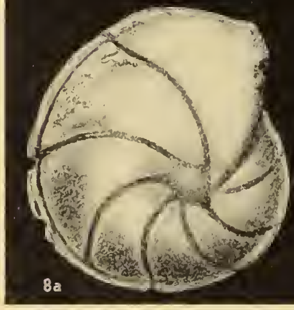
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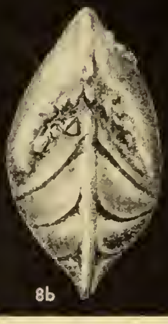
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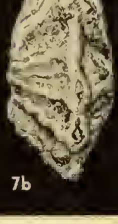
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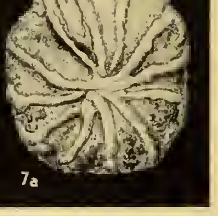
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PLATE 5

LAGINIDAE

1. *Robulus* cf. *R. adelinensis* Keijzer × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2264.

2. *Robulus cultratus* Montfort × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2263. Hypotype 43975.

3. *Robulus cultratus* Montfort × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43976.

4. *Robulus* cf. *R. calcar* (Linné) × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

5. *Robulus inornatus* (d'Orbigny) × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2264. Hypotype 43979.

6. *Robulus insuetus* Cushman and Stainforth × 25. U.C. Loc. B-2237. Hypotype 43982.

7. *Robulus insuetus* Cushman and Stainforth × 25. *a,* side view; *b,* apertural view. U.C. Loc. B-2237. Hypotype 43983.

8. *Robulus simplex* d'Orbigny × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2252. Hypotype 43992.

PLATE 6

LAGINIDAE

1. *Robulus* cf. *R. limbosus* (Reuss) var. *hockleyensis* Cushman and Applin × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2263.

2. *Robulus clericee* (Fornasini) var. *acies* Cushman and Renz × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43972.

3. *Robulus midwayensis* (Plummer) × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2263.

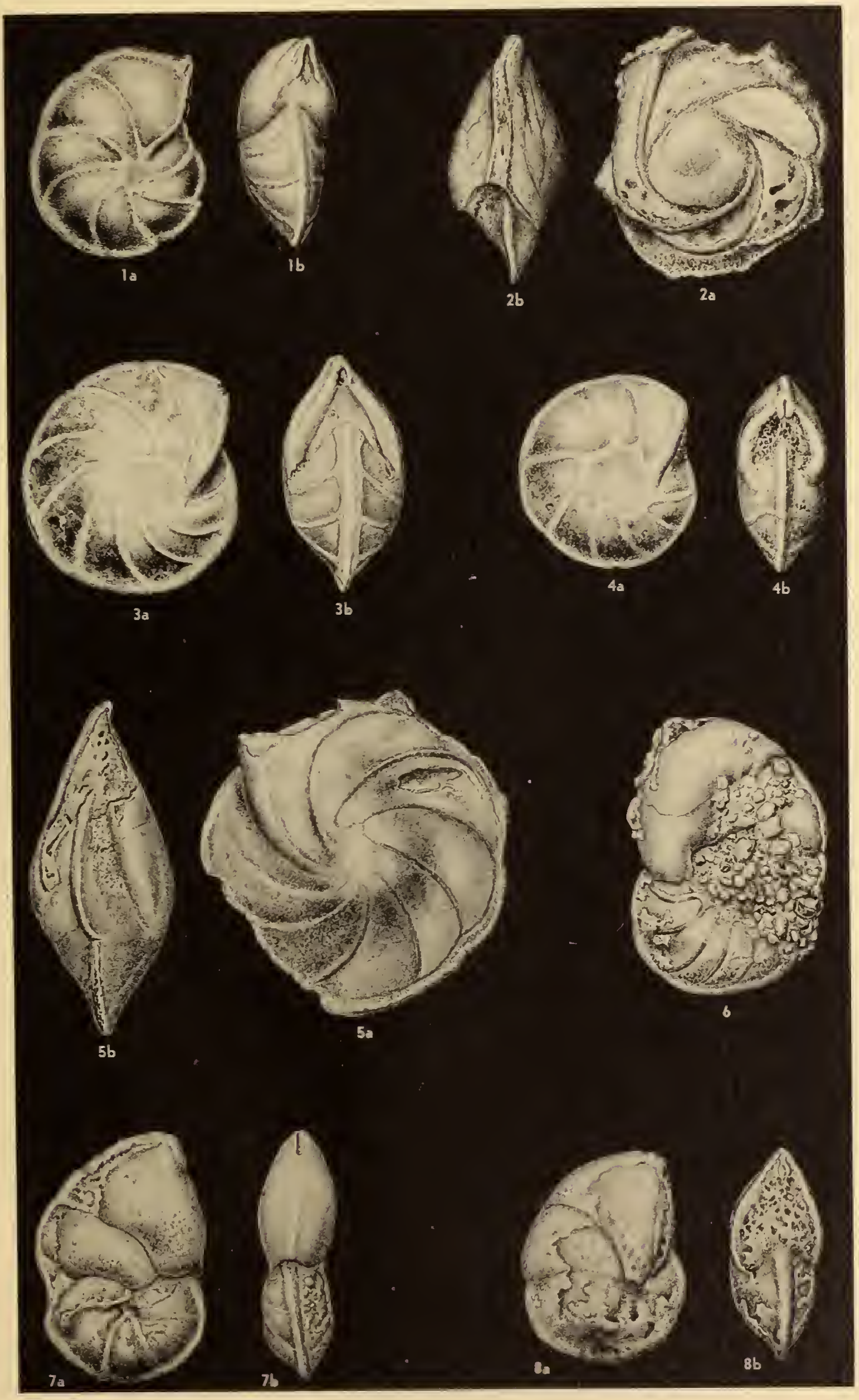
4. *Robulus warmani* Barbat and von Estorff × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2261. Hypotype 43996.

5. *Robulus* cf. *R. clypeiformis* d'Orbigny × 25. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

6. *Robulus propinquus cowlitzensis* Beck × 43. U.C. Loc. B-2267. Hypotype 43988.

7. *Robulus propinquus cowlitzensis* Beck × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2267. Hypotype 43989.

8. *Robulus propinquus cowlitzensis* Beck × 43. *a,* side view; *b,* apertural view. U.C. Loc. B-2267. Hypotype 43990.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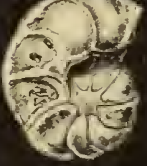
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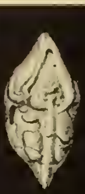
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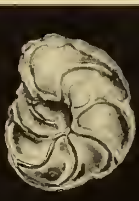
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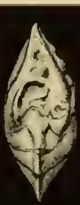
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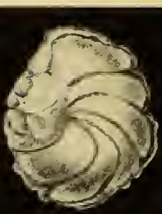
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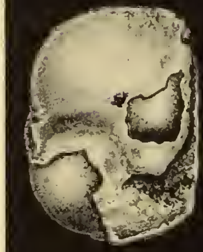
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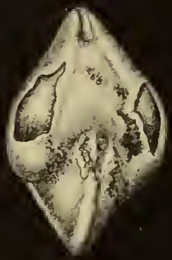
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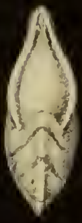
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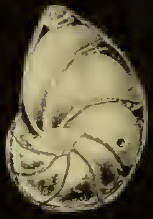
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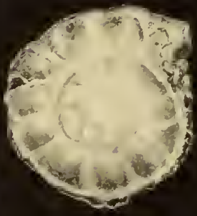
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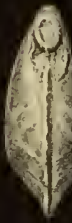
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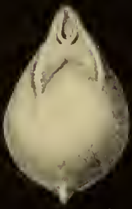
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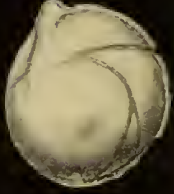
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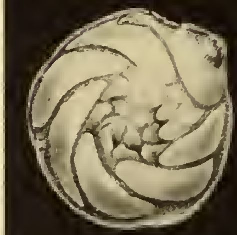
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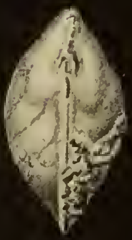
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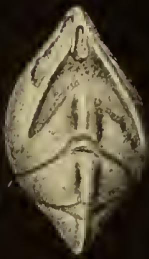
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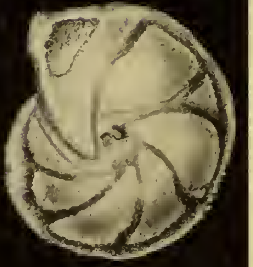
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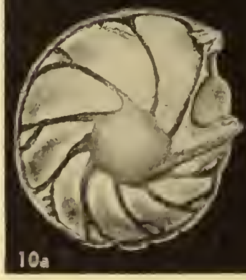
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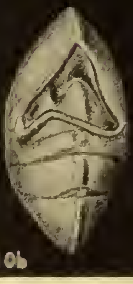
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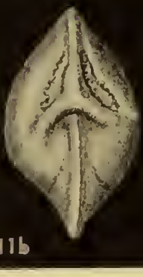
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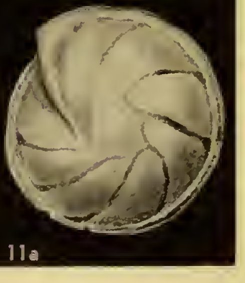
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PLATE 7

LAGINIDAE

1. *Robulus chiranus* Cushman and Stone × 50. U.C. Loc. B-2247. Hypotype 43970.

2. *Robulus chiranus* Cushman and Stone × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2251. Hypotype 43971.

3. *Robulus vortex* (Fichtel and Moll) × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2251.

4. *Robulus kincaidi* Beck × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

5. *Robulus mayi* Cushman and Parker × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

6. *Robulus* cf. *R. terryi* Coryell and Embich × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43993.

7. *Robulus* cf. *R. deformis* (Reuss) × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43977.

8. *Robulus arcuato-straitus* (Hantken) var. *carolinianus* Cushman × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2264.

9. *Robulus alato-limbatus* (Gümbel) × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43965.

10. *Robulus antipodum* (Stache) × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2264.

11. *Robulus* sp. × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43999.

PLATE 8

Laginidae

1. *Darbyella* sp. × 60. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

2. *Lenticulina* cf. L. convergens (Bornemann) × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43888.

3. *Planularia caribbeana* Bermudez × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43919.

4. *Planularia tolmani* Cushman and Simonson × 83. *a,* side view; *b,* peripheral view. U.C. Loc. B-2251. Hypotype 43921.

5. *Marginulina munda* Cushman × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43896.

6. *Marginulina* cf. *M. inconspicua* Hussey × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2266.

7. *Marginulina alazanensis* Nuttall × 50. *a,* side view; *b,* apertural view. U. C. Loc. B-2252. Hypotype 43892.

8. *Marginulina alazanensis* Nuttall × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2263. Hypotype 43893.

9. *Marginulina eximia* Neugeboren × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2264.

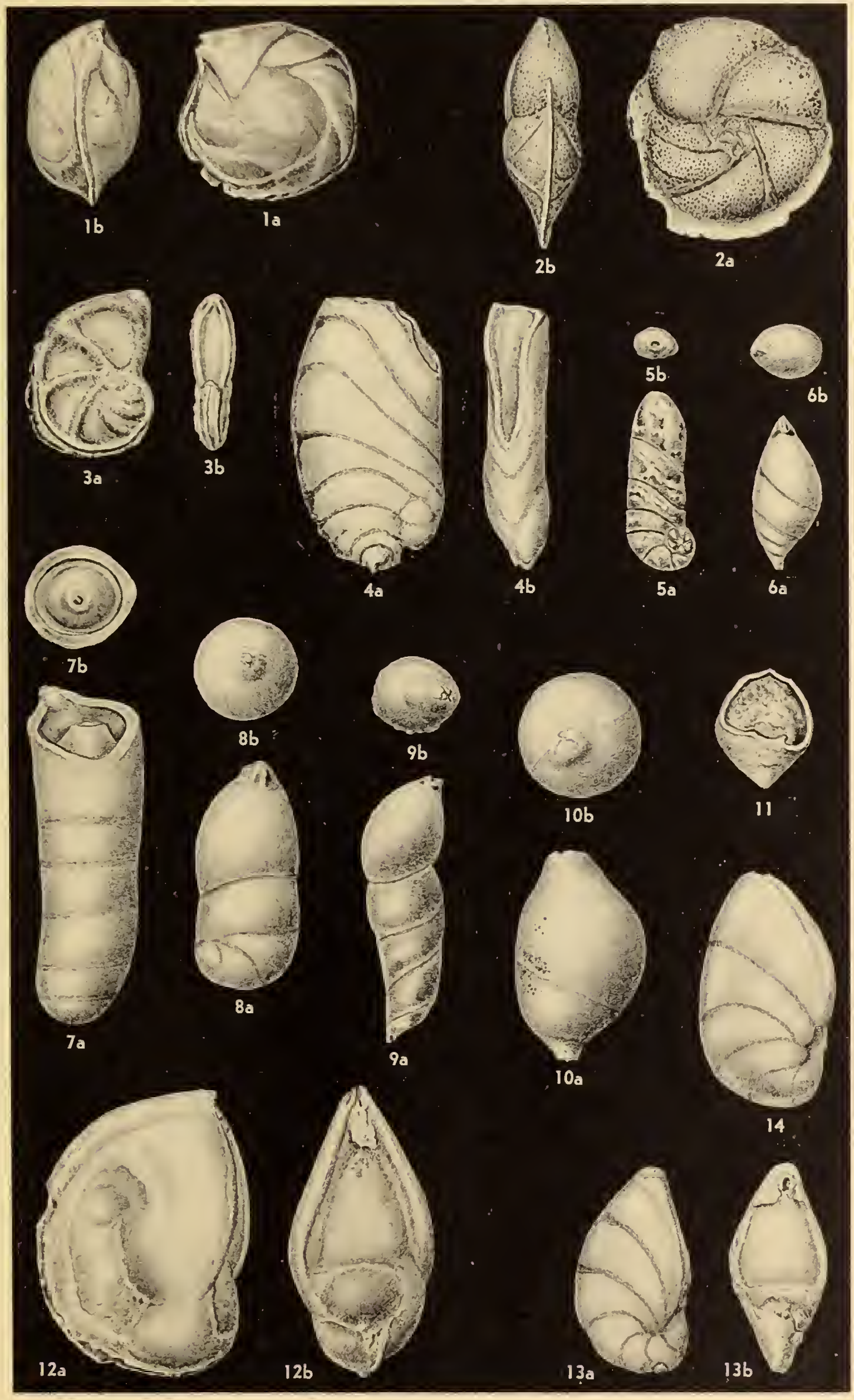
10. *Marginulina* cf. *M. adunca* (Costa) × 61. *a,* side view; *b,* apertural view. U.C. Loc. B-2276. Hypotype 43891.

11. *Marginulina* cf. *M. adunca* (Costa) × 50. U.C. Loc. B-2267. Hypotype 43890.

12. *Saracenaria ?* cf. *S. acutiauricularis* (d'Orbigny) × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

13. *Saracenaria hantkeni* (Cushman) × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2252. Hypotype 44001.

14. *Saracenaria hantkeni* (Cushman) × 50. U.C. Loc. B-2252. Hypotype 44002.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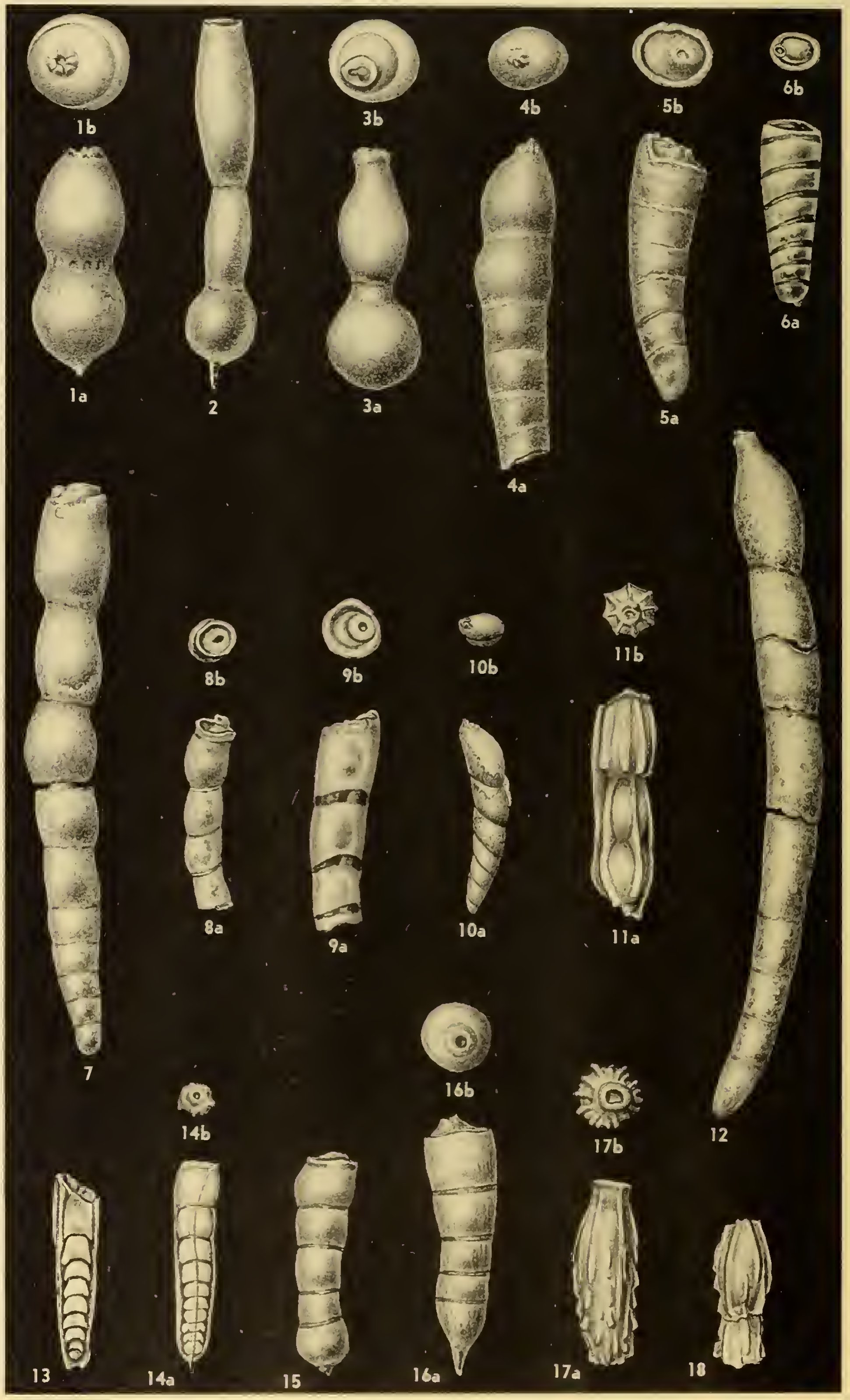
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PLATE 9

LAGINIDAE

1. *Dentalina* cf. *D. catenula* Reuss × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2252.

2. *Dentalina consobrina* d'Orbigny × 50. U.C. Loc. B-2228. Hypotype 43791.

3. *Dentalina consobrina* d'Orbigny × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43793.

4. *Dentalina cooperensis* Cushman × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43794.

5. *Dentalina cooperensis* Cushman × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43795.

6. *Dentalina colei* Cushman and Dusenbury × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2251.

7. *Dentalina pauperata* (d'Orbigny) × 50. U.C. Loc. B-2228.

8. *Dentalina* cf. *D. hantkeni* Cushman × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2267.

9. *Dentalina jarvisi* Cushman and Todd × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2252. Hypotype 43797.

10. *Dentalina* cf. *D. legumen* Reuss × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

11. *Dentalina pioneerensis* Kleinpell × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2252.

12. *Dentalina nasuta* Cushman × 50. U.C. Loc. B-2228.

13. *Dentalina quadrulata* Cushman and Laiming × 50. U.C. Loc. B-2277. Hypotype 43805.

14. *Dentalina quadrulata* Cushman and Laiming × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43804.

15. *Dentalina* sp. × 50. U.C. Loc. B-2264. Hypotype 43808.

16. *Dentalina* sp. × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43809.

17. *Dentalina spinosa* d'Orbigny × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43806.

18. *Dentalina spinosa* d'Orbigny × 50. U.C. Loc. B-2228. Hypotype 43807.

PLATE 10

LAGINIDAE

1. *Nodosaria longiscata* d'Orbigny × 50. U.C. Loc. B-2228.

2. *Nodosaria holserica* Schwager × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

3. *Nodosaria pyrula* d'Orbigny × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43911.

4. *Nodosaria pyrula* d'Orbigny × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 43912.

5. *Nodosaria* cf. *N. soluta* (Reuss) × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

6. *Nodosaria anomala* Reuss × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2266.

7. *Nodosaria ewaldi* Reuss × 50. U.C. Loc. B-2277.

8. *Nodosaria parexilis* Cushman and Stewart var. *sentifera* Cushman and Parker × 50. U.C. Loc. B-2263.

9. *Lagena hexagona* (Williamson) × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2258.

10. *Lagena conscripta* Cushman and Barksdale × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2267.

11. *Lagena* cf. *L. substriata* Williamson × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2267.

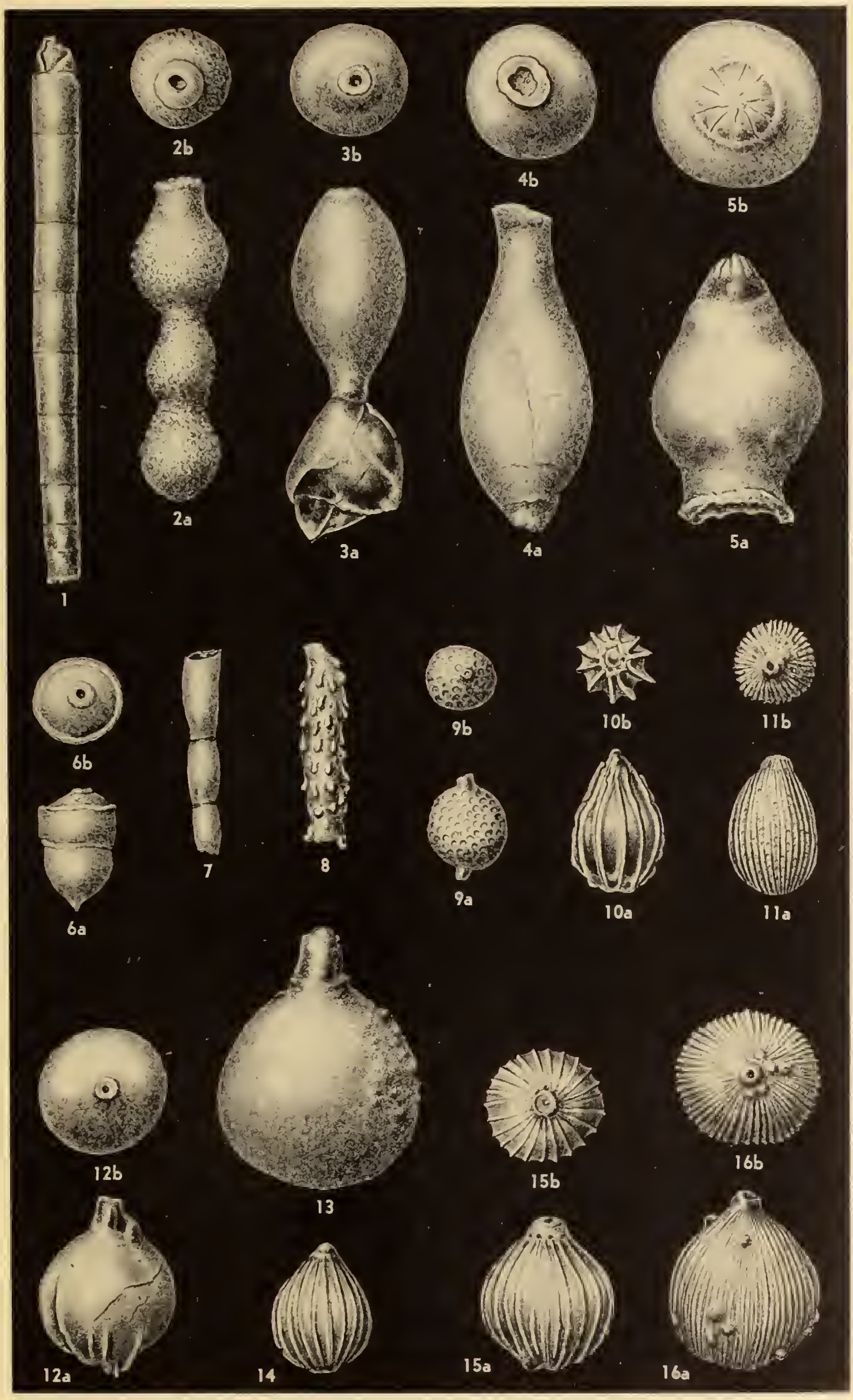
12. *Lagena vulgaris* Williamson × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2266. Hypotype 43886.

13. *Lagena vulgaris* Williamson × 83. U.C. Loc. B-2277. Hypotype 43887.

14. *Lagena strumosa* Reuss × 83. U.C. Loc. B-2264. Hypotype 43884.

15. *Lagena strumosa* Reuss × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2263. Hypotype 43883.

16. *Lagena becki* Sullivan n. sp. × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2264. Holotype 43879.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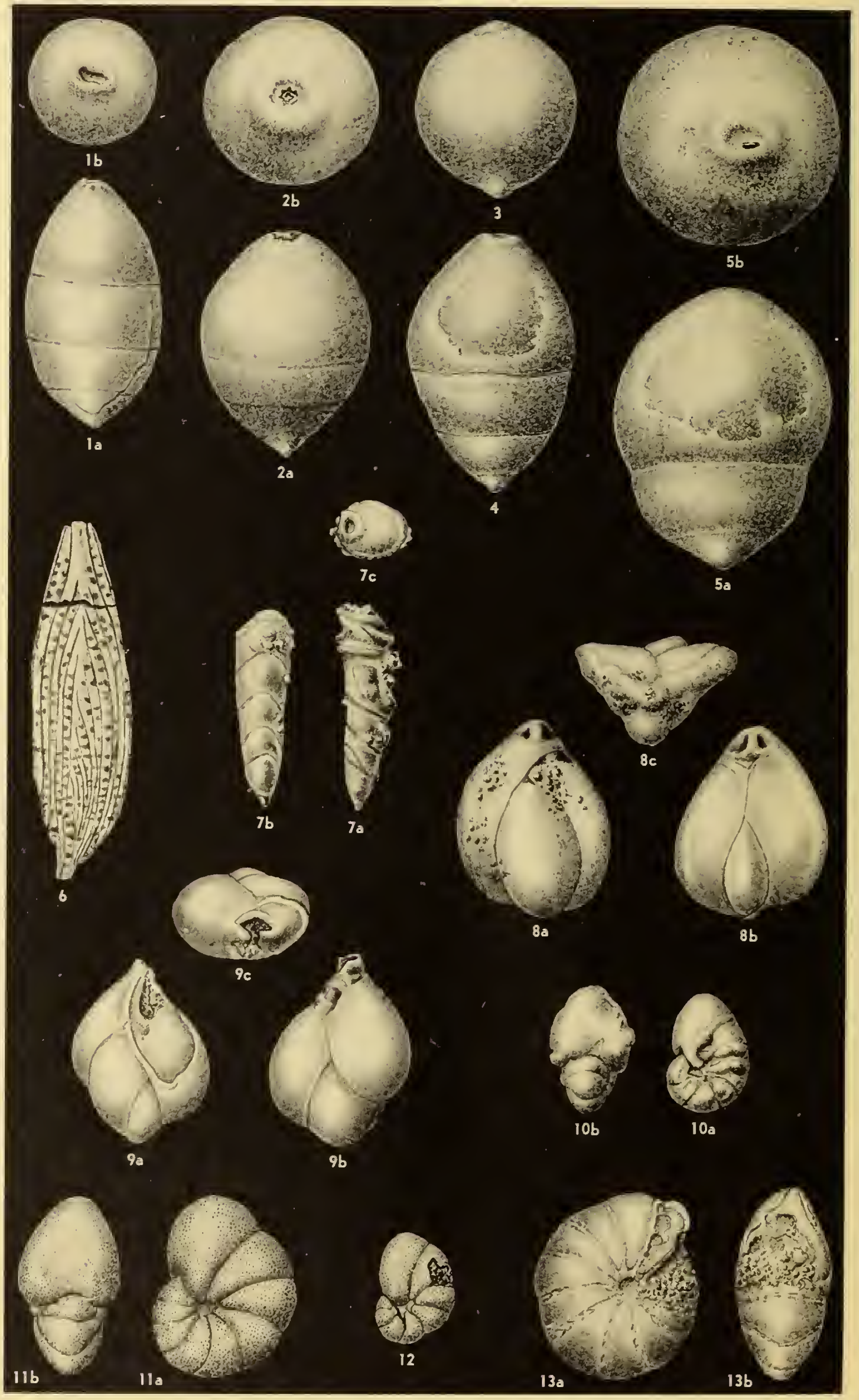
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PLATE 11

LAGINIDAE, POLYMORPHINIDAE, NONIONIDAE

1. *Pseudoglandulina* cf. *P. manifesta* (Reuss) ×50. *a,* side view; *b,* apertural view. U.C. Loc. B-2264.

2. *Pseudoglandulina ovata* (Cushman and Applin) ×50. *a,* side view; *b,* apertural view. U.C. Loc. B-2263. Hypotype 43953.

3. *Pseudoglandulina ovata* (Cushman and Applin) ×50. U.C. Loc. B-2277. Hypotype 43955.

4. *Pseudoglandulina ovata* (Cushman and Applin) ×50. U.C. Loc. B-2277. Hypotype 43954.

5. *Pseudoglandulina* sp. ×50. *a,* side view; *b,* apertural view. U.C. Loc. B-2276.

6. *Frondicularia tenuissima* Hantken ×71. U.C. Loc. B-2228. Hypotype 43842.

7. *Enantiodentalina obliquisuturata* (Stache) ×43. *a,* side view; *b,* peripheral view; *c,* apertural view. U.C. Loc. B-2252.

8. *Guttulina irregularis* d'Orbigny ×43. *a, b,* opposite sides; *c,* apertural view. U.C. Loc. B-2252.

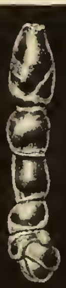
9. *Guttulina problema* d'Orbigny ×43. *a, b,* opposite sides; *c,* apertural view. U.C. Loc. B-2266.

10. *Nonionella* cf. *N. miocenica* Cushman ×71. *a,* ventral view; *b,* apertural view. U.C. Loc. B-2277.

11. *Nonion* cf. *N. labradoricum* Dawson ×71. *a,* side view; *b,* apertural view. U.C. Loc. B-2275. Hypotype 43915.

12. *Nonion* cf. *N. labradoricum* Dawson ×71. U.C. Loc. B-2263. Hypotype 43914.

13. *Elphidium* cf. *E. californicum* Cook MS. ×43. *a,* side view; *b,* apertural view. U.C. Loc. B-2253.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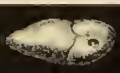
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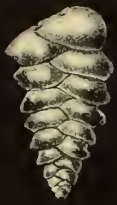
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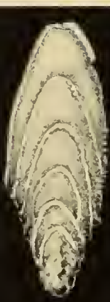
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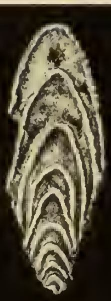
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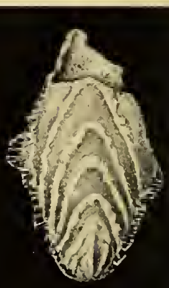
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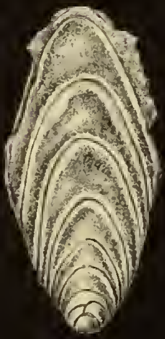
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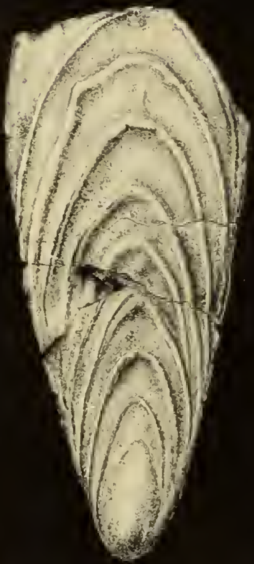
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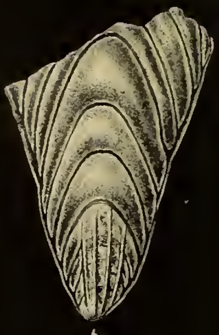
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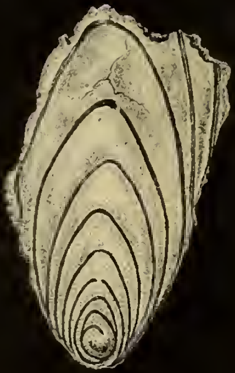
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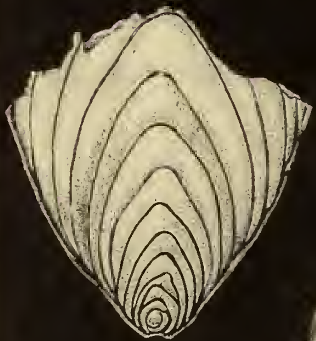
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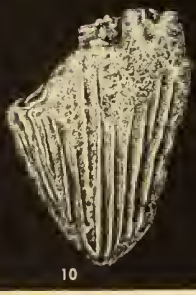
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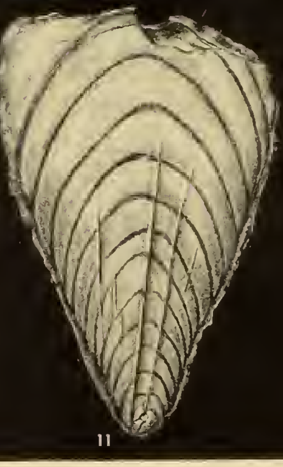
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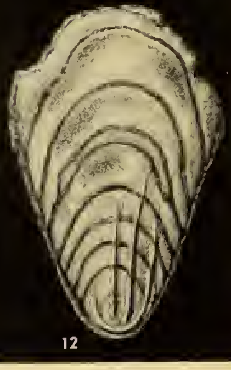
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PLATE 12

HETEROHELICIDAE

1. *Rectogümbelina* cf. *R. trinitatensis* Cushman and Renz × 62. U.C. Loc. B-2228.

2. *Bolivinoides mexicanus* (Cole) × 62. *a,* side view; *b,* apertural view. U.C. Loc. B-2234.

3. *Plectofrondicularia* cf. *P. basi-spinata* Cushman × 38. *a,* side view; *b,* section. U.C. Loc. B-2263. Hypotype 43930.

4. *Plectofrondicularia* cf. *P. basi-spinata* Cushman × 38. U.C. Loc. B-2263. Hypotype 43931.

5. *Plectofrondicularia virginiana* Cushman and Cederstrom × 44. U.C. Loc. B-2256.

6. *Plectofrondicularia miocenica* Cushman × 44. U.C. Loc. B-2277. Hypotype 43940.

7. *Plectofrondicularia vaughani* Cushman × 38. U.C. Loc. B-2271.

8. *Plectofrondicularia* cf. *P. vaughani* Cushman × 31. U.C. Loc. B-2228. Hypotype 43948.

9. *Plectofrondicularia* cf. *P. vaughani* Cushman × 38. U.C. Loc. B-2228. Hypotype 43949.

10. *Plectofrondicularia packardi* Cushman and Schenck var. *multilineata* Cushman and Simonson × 38. U.C. Loc. B-2255.

11. *Plectofrondicularia packardi packardi* Cushman and Schenck × 38. U.C. Loc. B-2252. Hypotype 43943.

12. *Plectofrondicularia packardi packardi* Cushman and Schenck × 38. U.C. Loc. B-2252. Hypotype 43944.

PLATE 13

HETEROHELICIDAE

1. *Plectofrondicularia minuta* Sullivan n. sp. × 83. U.C. Loc. B-2236. Holotype 43935.

2. *Plectofrondicularia minuta* Sullivan n. sp. × 83. U.C. Loc. B-2236. Paratype 43936.

3. *Plectofrondicularia minuta* Sullivan n. sp. × 83. U.C. Loc. B-2236. Paratype 43937.

4. *Plectofrondicularia minuta* Sullivan n. sp. × 83. U.C. Loc. B-2242. Paratype 43938.

5. *Plectofrondicularia* cf. *P. oregonensis* Cushman, R. E. and K. C. Stewart × 58. U.C. Loc. B-2243.

6. *Plectofrondicularia kerni* (Cook) MS. × 50. U.C. Loc. B-2228. Hypotype 43934.

7. *Plectofrondicularia kerni* (Cook) MS. × 50. U.C. Loc. B-2228. Hypotype 43932.

8. *Plectofrondicularia Kerni* (Cook) MS. × 50. U.C. Loc. B-2228. Hypotype 43933.

9. *Plectofrondicularia searsi* Cushman, R. E. and K. S. Stewart × 50. U.C. Loc. B-2252.

10. *Plectofrondicularia vokesi* Cushman, R. E. and K. C. Stewart × 58. U.C. Loc. B-2241.

11. *Plectofrondicularia trinitatensis* Cushman and Jarvis × 50. U.C. Loc. B-2228.

12. *Amphimorphina ignota* Cushman and Siegfus × 50. *a*, side view; *b*, apertural view. U.C. Loc. B-2228. Hypotype 43727.

13. *Amphimorphina ignota* Cushman and Siegfus × 50. *a*, side view; *b*, apertural view. U.C. Loc. B-2228. Hypotype 43726.

14. *Amphimorphina* aff. *A. ignota* Cushman and Siegfus × 50. U.C. Loc. B-2228.

15. *Amphimorphina jenkinsi* (Church) × 50. U.C. Loc. B-2231.

16. *Amphimorphina* cf. *A. jenkinsi* (Church) × 50. *a*, side view; *b*, apertural view. U.C. Loc. B-2255.

17. *Nodogenerina adolphina* (d'Orbigny) × 50. *a*, side view; *b*, apertural view. U.C. Loc. B-2228.

18. *Nodogenerina* sp. × 50. U.C. Loc. B-2228.

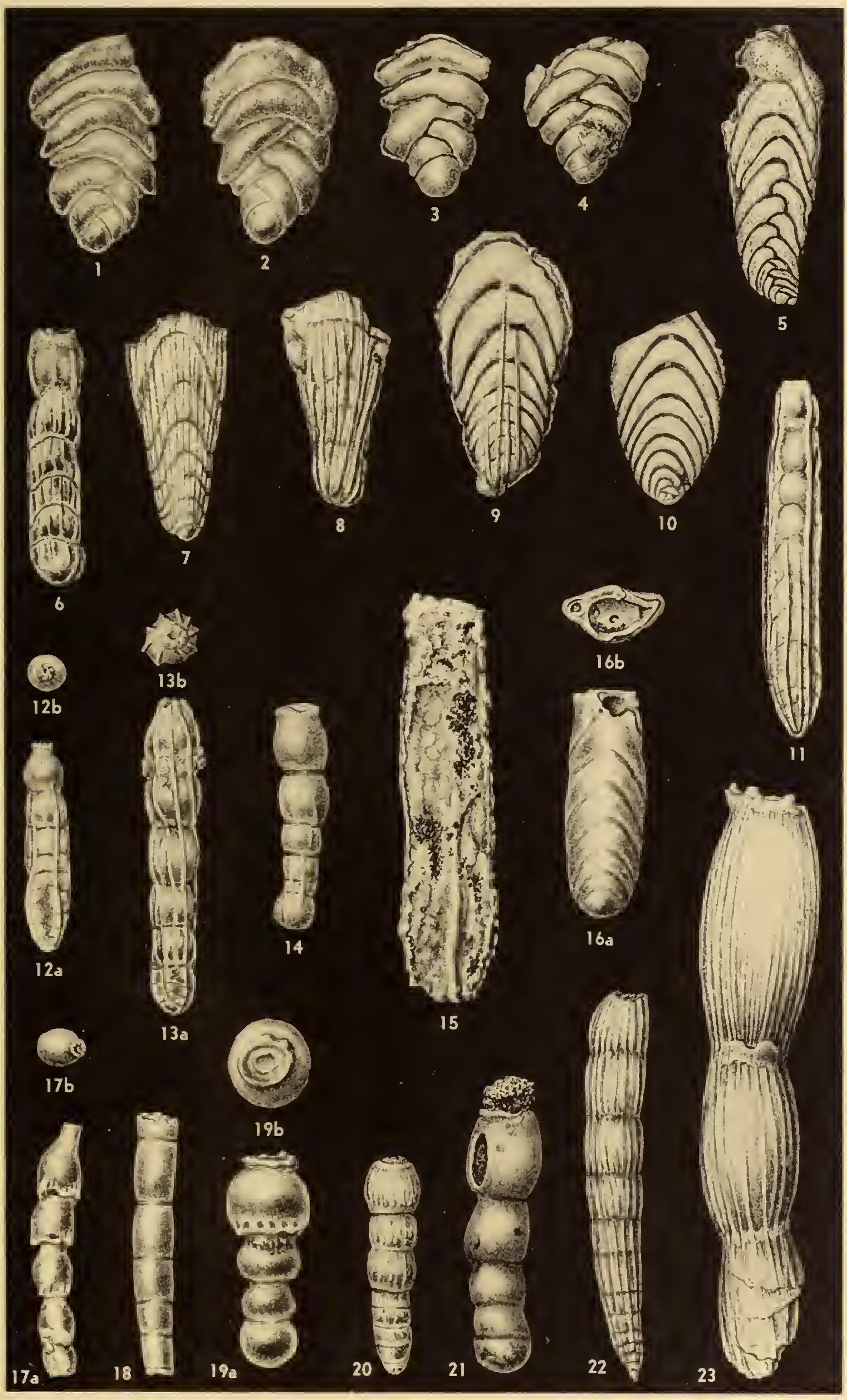
19. *Nodogenerina sanctaecrucis* Kleinpell × 50. *a*, side view; *b*, apertural view. U.C. Loc. B-2233.

20. *Nodogenerina advena* Cushman and Laiming × 50. U.C. Loc. B-2263. Hypotype 43901.

21. *Nodogenerina advena* Cushman and Laiming × 50. U.C. Loc. B-2262. Hypotype 43900.

22. *Nodogenerina wegemanni* (Cole) × 50. U.C. Loc. B-2228. Hypotype 43903.

23. *Nodogenerina wegemanni* (Cole) × 50. U.C. Loc. B-2228. Hypotype 43904.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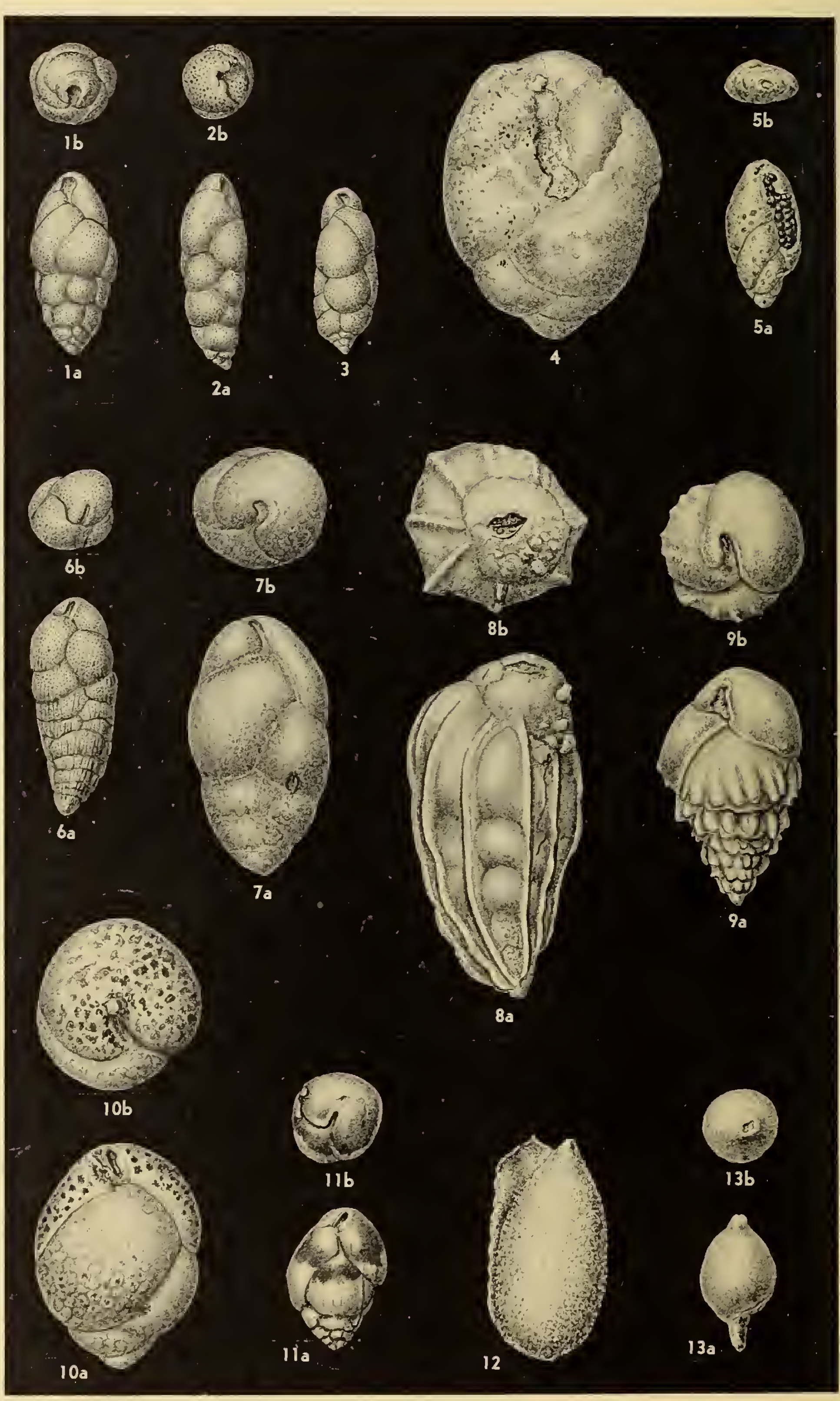
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PLATE 14

BULIMINIDAE

1. *Buliminella curta* Cushman × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2270.

2. *Buliminella subfusiformis* Cushman × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43764.

3. *Buliminella subfusiformis* Cushman × 58. U.C. Loc. B-2277. Hypotype 43765.

4. *Bulimina guayabalensis* Cole var. *ampla* Cushman and Parker × 50. U.C. Loc. B-2251.

5. *Bulimina* cf. *B. kugleri* Cushman and Renz × 50. *a,* side view; *b,* apertural *view.* U.C. Loc. B-2271.

6. *Bulimina microcostata* Cushman and Parker × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2234. Hypotype 43754.

7. *Bulimina ovata* d'Orbigny × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

8. *Bulimina sculptilis* Cushman × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2251. Hypotype 43759.

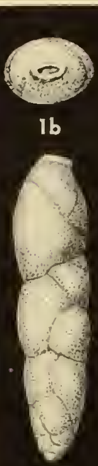
9. *Bulimina rinconensis* Cushman and Laiming × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

10. *Bulimina* cf. *B. socialis* Bornemann × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

11. *Bulimina* cf. *B. stalacta* Cushman and Parker × 50. *a,* side view; *b,* apertural view. U.C. Loc. B-2243.

12. *Globobulimina* cf. *G. pacifica* Cushman × 83. U.C. Loc. B-2263.

13. *Entosolenia* cf. *E. apiculata* (Reuss) × 83. *a,* side view; *b,* apertural view. U.C. Loc. B-2245.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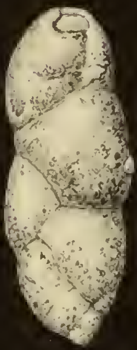
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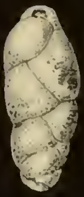
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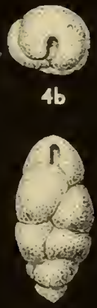
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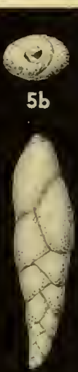
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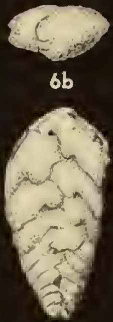
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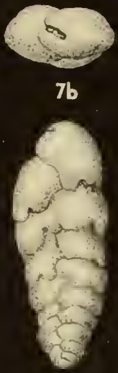
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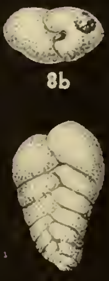
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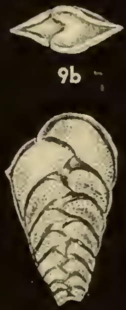
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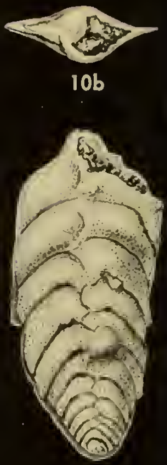
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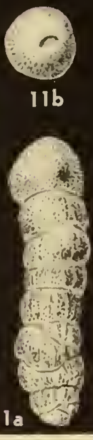
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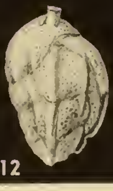
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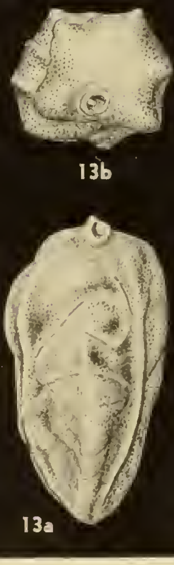
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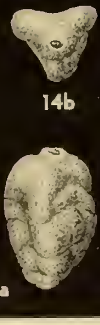
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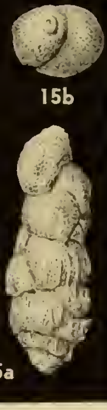
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PLATE 15

Buliminidae

1. *Virgulina bramlettei* Galloway and Morrey × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2271. Hypotype 44034.

2. *Virgulina bramlettei* Galloway and Morrey × 58. U.C. Loc. B-2228. Hypotype 44033.

3. *Virgulina californiensis* Cushman × 58. U.C. Loc. B-2233. Hypotype 44035.

4. *Virgulina californiensis* Cushman × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2255. Hypotype 44036.

5. *Virgulina dibollensis* Cushman and Applin × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

6. *Bolivina kleinpelli* Beck × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2239.

7. *Bolivina gracilis* Cushman and Applin var. *incisurata* Cushman × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2229.

8. *Bolivina gracilis* Cushman and Applin × 71. *a,* side view; *b,* apertural *view.* U.C. Loc. B-2236.

9. *Bolivina marginata* Cushman × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2256.

10. *Bolivina pisciformis* Galloway and Morrey × 71. *a,* side view; *b,* apertural view. U.C. Loc. B-2263. Hypotype 43749.

11. *Bifarina eleganta* (Plummer) × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2228.

12. *Angulogerina* sp. × 58. U.C. Loc. B-2277. Hypotype 43735.

13. *Angulogerina* sp. × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 43734.

14. *Angulogerina* cf. *A. wilcoxensis* Cushman and Ponton × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2234. Hypotype 43732.

15. *Angulogerina occidentalis* Cushman × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2271.

PLATE 16

BULIMINIDAE

1. *Uvigerina auberiana* d'Orbigny × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 44018.

2. *Uvigerina garzaensis* Cushman and Siegfus × 58. U.C. Loc. B-2228. Hypotype 44022.

3. *Uvigerina garzaensis* Cushman and Siegfus × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2228. Hypotype 44021.

4. *Uvigerina garzaensis* Cushman and Siegfus var. *nudo-robusta* Mallory × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2251. Hypotype 44023.

5. *Uvigerina atwilli* Cushman and Simonson × 58. U.C. Loc. B-2256. Hypotype 44015.

6. *Uvigerina atwilli* Cushman and Simonson × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2256. Hypotype 44016.

7. *Uvigerina atwilli* Cushman and Simonson × 58. U.C. Loc. B-2256. Hypotype 44017.

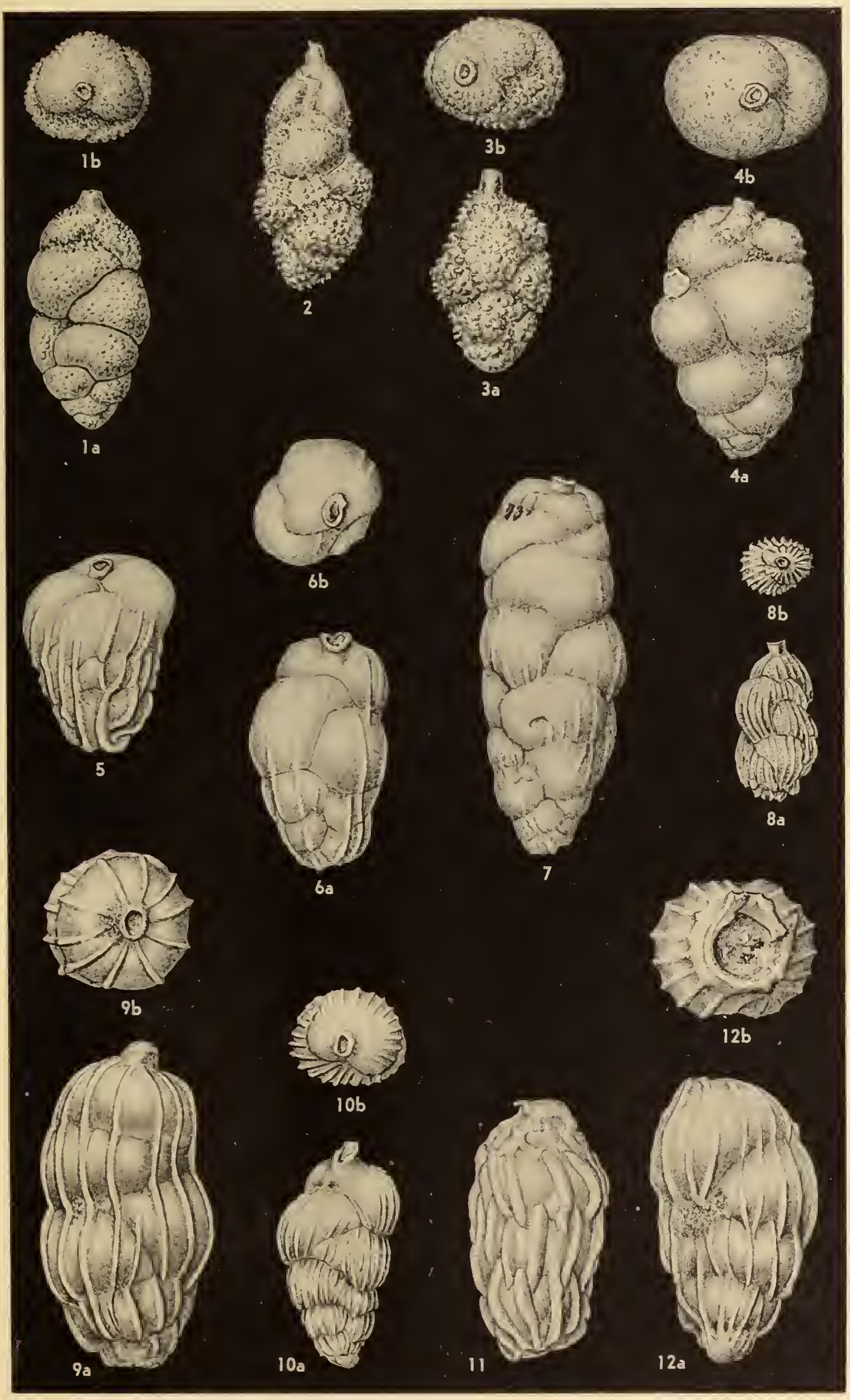
8. *Hopkinsina compressa* (Cushman) × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

9. *Uvigerina gallowayi* Cushman × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2277.

10. *Uvigerinella obesa* Cushman var. *impolita* Cushman and Laiming × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2268.

11. *Siphogenerina* cf. *S. smithi* Kleinpell × 58. U.C. Loc. B-2268. Hypotype 44003.

12. *Siphogenerina* cf. *S. smithi* Kleinpell × 58. *a,* side view; *b,* apertural view. U.C. Loc. B-2277. Hypotype 44004.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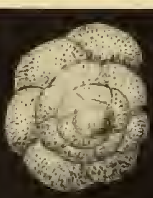
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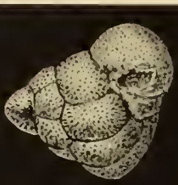
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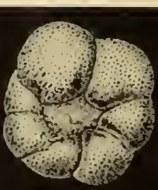
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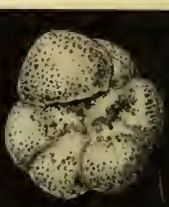
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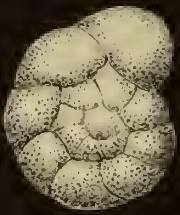
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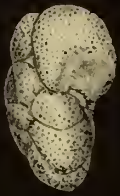
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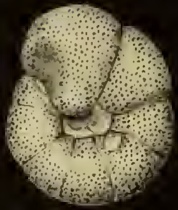
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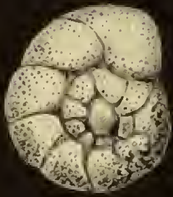
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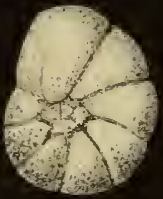
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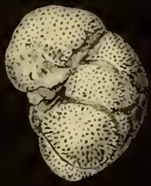
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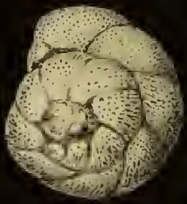
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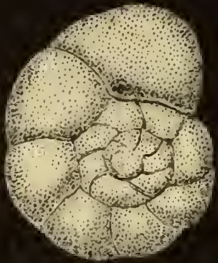
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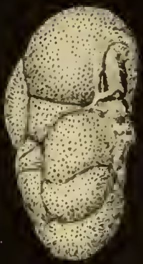
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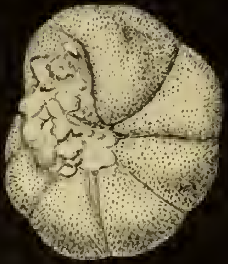
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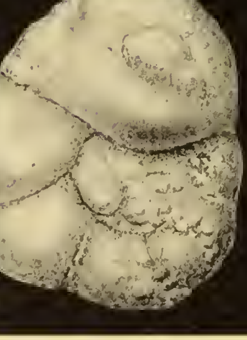
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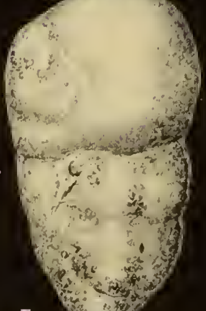
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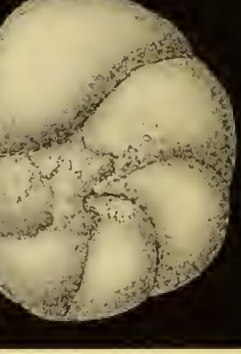
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PLATE 17

ROTALIDAE

1. *Valvulineria tumeyensis* Cushman and Simonson var. *conica* Sullivan × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2238. Holotype 44030.

2. *Valvulineria tumeyensis* Cushman and Simonson var. *conica* Sullivan × 67. ventral view. U.C. Loc. B-2238. Paratype 44031.

3. *Valvulineria tumeyensis* Cushman and Simonson × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U. C. Loc. B-2234. Hypotype 44027.

4. *Valvulineria tumeyensis* Cushman and Simonson × 67. *a,* dorsal view; *b,* ventral view. U.C. Loc. B-2239. Hypotype 44028.

5. *Valvulineria tumeyensis* Cushman and Simonson × 67. *a,* dorsal view; *b,* peripheral view. U.C. Loc. B-2245. Hypotype 44029.

6. *Valvulineria tumeyensis* Cushman and Simonson × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2234. Hypotype 44026.

7. *Valvulineria* cf. *V. wilcoxensis* Cushman and Ponton × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2229.

PLATE 18

Rotalidae

1. *Gyroidina orbicularis* d'Orbigny var. *planata* Cushman × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2262.

2. *Gyroidina condoni* (Cushman and Schenck) × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2239. Hypotype 43859.

3. *Gyroidina planulata* Cushman and Renz × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2265. Hypotype 43862.

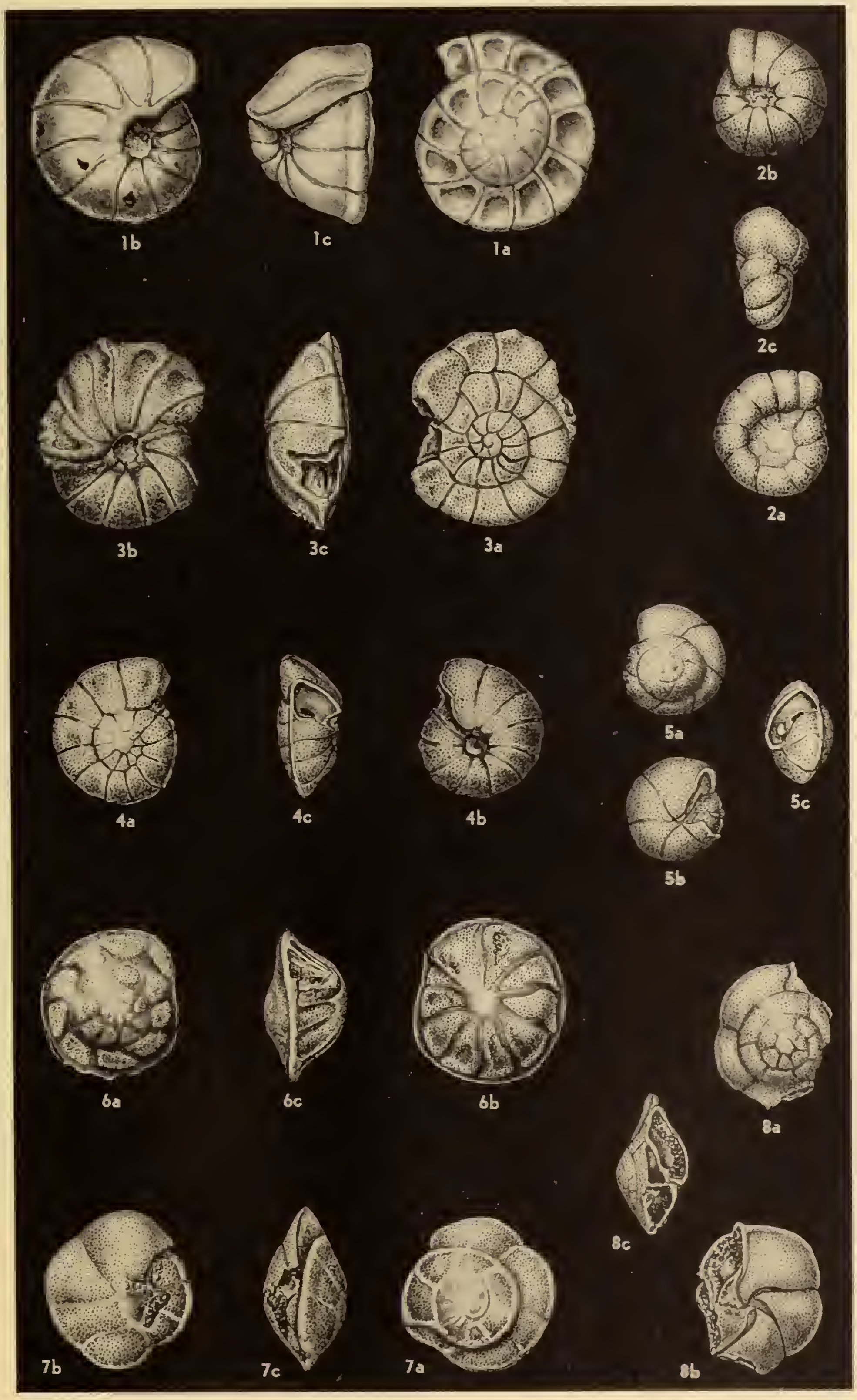
4. *Gyroidina planulata* Cushman and Renz × 67. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2265. Hypotype 43863.

5. *Eponides keenani* Cushman and Kleinpell × 50. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2277.

6. *Eponides lodoensis* Martin var. *martini* Smith × 50. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228.

7. *Eponides umbonatus* (Reuss) × 50. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. loc. B-2228. Hypotype 43838.

8. *Eponides umbonatus* (Reuss) × 50 *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2277. Hypotype 43839.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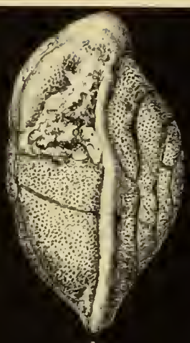
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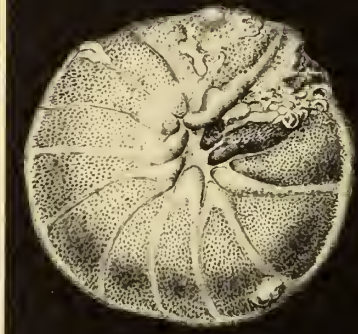
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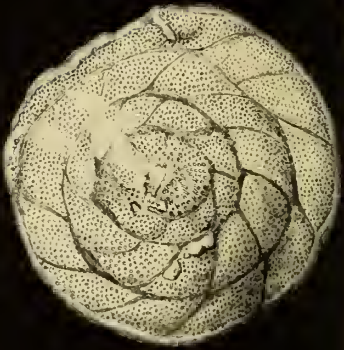
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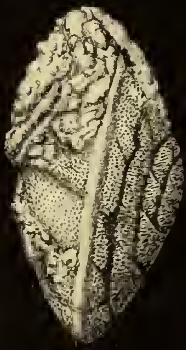
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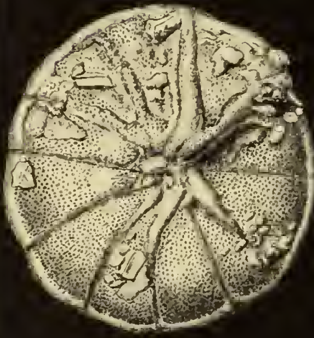
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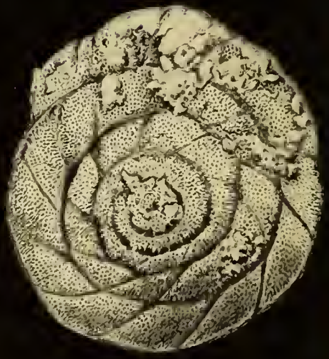
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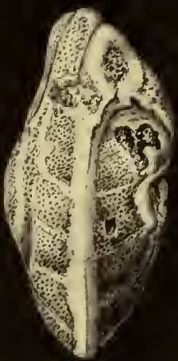
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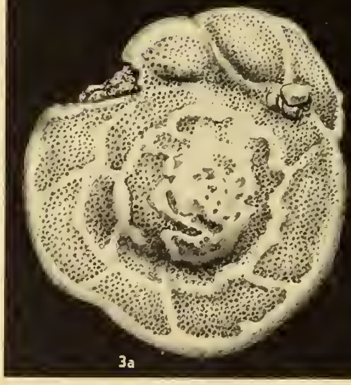
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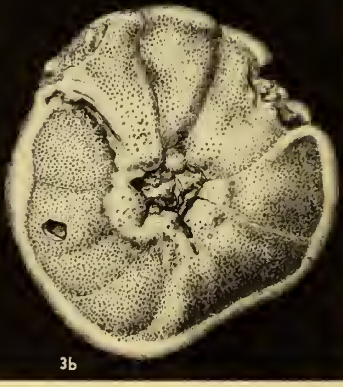
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PLATE 19

ROTALIDAE

1. *Eponides kleinpelli* Cushman and Frizzell × 38. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2275. Hypotype 43834.

2. *Eponides kleinpelli* Cushman and Frizzell × 38. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2275. Hypotype 43835.

3. *Epistomina ramonensis* Cushman and Kleinpell × 38. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2263.

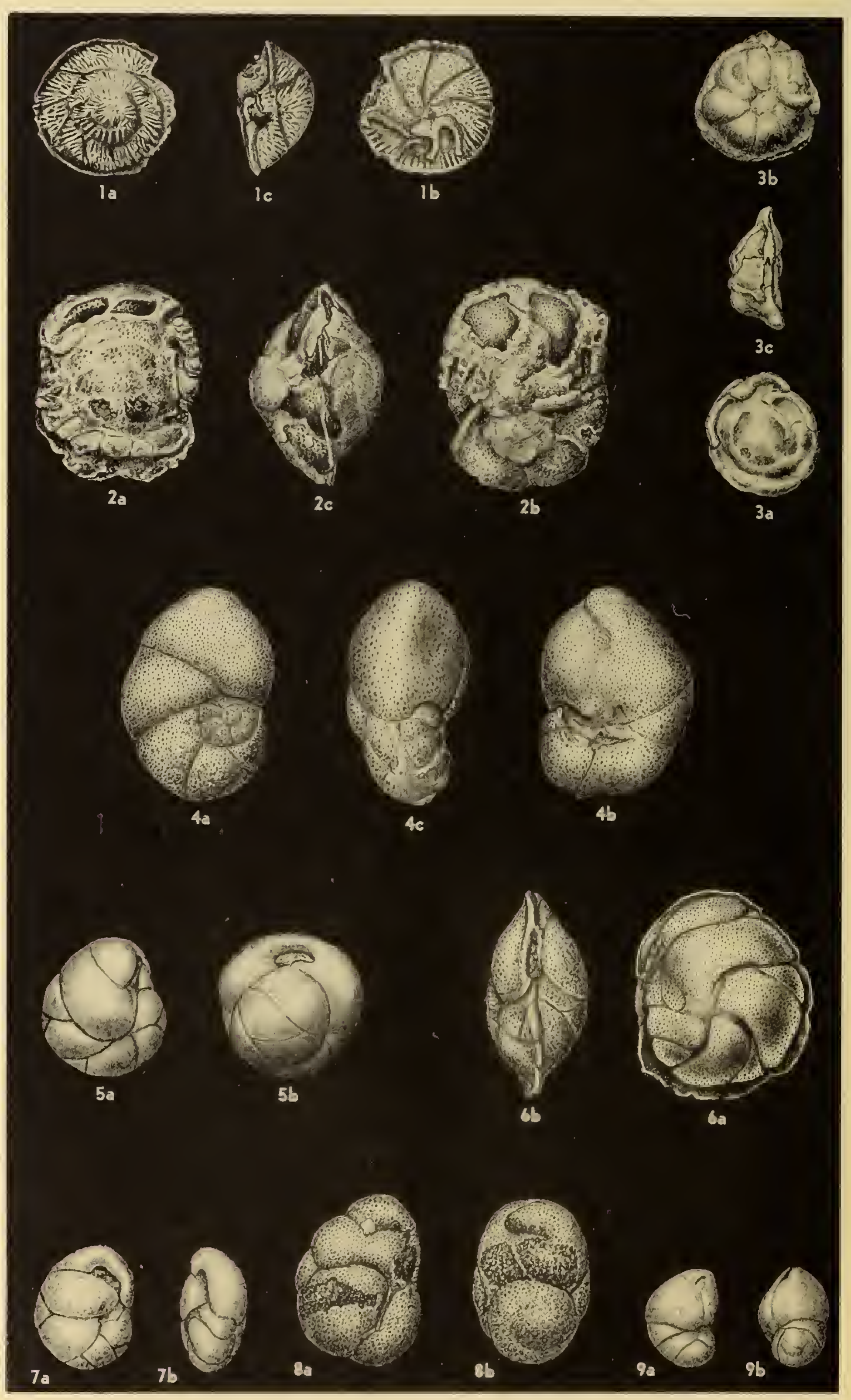
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PLATE 20

ROTALIDAE, AMPHISTEGINIDAE, CASSIDULINIDAE

1. *Eponides* cf. *E. mexicana* Cushman × 50. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2253.

2. *Epistomina eocenica* Cushman and M. A. Hanna × 50. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228.

3. *Asterigerina crassaformis* Cushman and Siegfus × 58. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228.

4. *Cancris mexicanus* Cushman and Todd × 50. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2229.

5. *Cassidulina globosa* Hantken × 58. *a,* side view; *b,* peripheral view. U.C. Loc. B-2262.

6. *Cassidulina crassipunctata* Cushman and Hobson × 58. *a,* side view; *b,* peripheral view. U.C. Loc. B-2263.

7. *Cassidulina* cf. *C. diversa* Cushman and Stone × 58. *a,* side view; *b,* peripheral view. U.C. Loc. B-2233. Hypotype 43768.

8. *Stichocassidulina* cf. *S. thalmanni* Stone × 58. *a,* side view; *b,* peripheral view. U.C. Loc. B-2233.

9. *Cassidulinoides californiensis* Bramlette × 58. *a,* side view; *b,* peripheral view. U.C. Loc. B-2257. Hypotype 43771.

PLATE 21

Ellipsoidinidae, Chilostomellidae

1. *Ellipsonodosaria* cf. *E. alexanderi* Cushman × 43. U.C. Loc. B-2228.

2. *Ellipsonodosaria atlantisae* Cushman × 43. U.C. Loc. B-2228.

3. *Ellipsonodosaria spinulosa* (Montagu) × 43. U.C. Loc. B-2228. Hypotype 43827.

4. *Ellipsonodosaria spinulosa* (Montagu) × 43. U.C. Loc. B-2228. Hypotype 43826.

5. *Ellipsonodosaria* cf. *E. nuttalli* Cushman and Jarvis × 43. U.C. Loc. B-2271.

6. *Ellipsonodosaria recta* Palmer and Bermudez × 43. *a*, side view; *b*, apertural view. U.C. Loc. B-2263.

7. *Ellipsonodosaria* (?) cf. *E. jarvisi* Cushman × 36. *a*, side view; *b*, apertural view. U.C. Loc. B-2231. Hypotype 43822.

8. "*Ellipsonodosaria* sp. *A.*" Cushman and Siegfus × 43. U.C. Loc. B-2241. Hypotype 43829.

9. "*Ellipsonodosaria* sp. *A.*" Cushman and Siegfus × 43. U.C. Loc. B-2228. Hypotype 43828.

10. *Chilostomella hadleyi* Keijzer × 43. U.C. Loc. B-2228. Hypotype 43773.

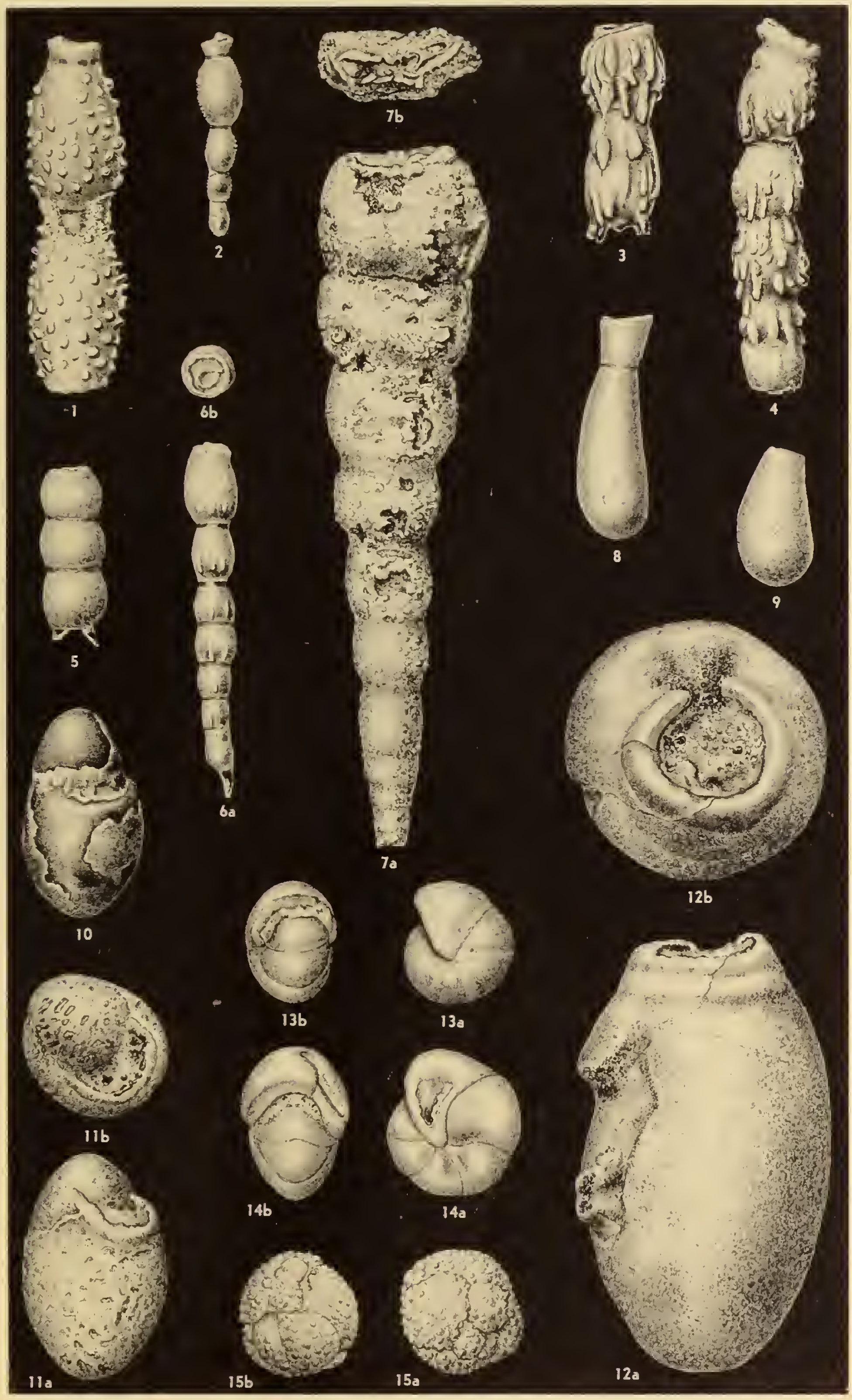
11. *Chilostomelloides ovicula* Nuttall × 43. *a*, side view; *b*, apertural view. U.C. Loc. B-2228.

12. *Chilostomelloides oviformis* (Sherborn and Chapman) × 43. *a*, side view; *b*, apertural view. U.C. Loc. B-2228.

13. *Pullenia eocenica* Cushman and Siegfus × 61. *a*, side view; *b*, apertural view. U.C. Loc. B-2228.

14. *Pullenia quinqueloba* (Reuss) var. *angusta* Cushman and Todd × 61. *a*, side view; *b*, apertural view. U.C. Loc. B-2228.

15. *Sphaeroidina gredalensis* Cook MS × 61. *a*, side view; *b*, apertural view. U.C. Loc. B-2228.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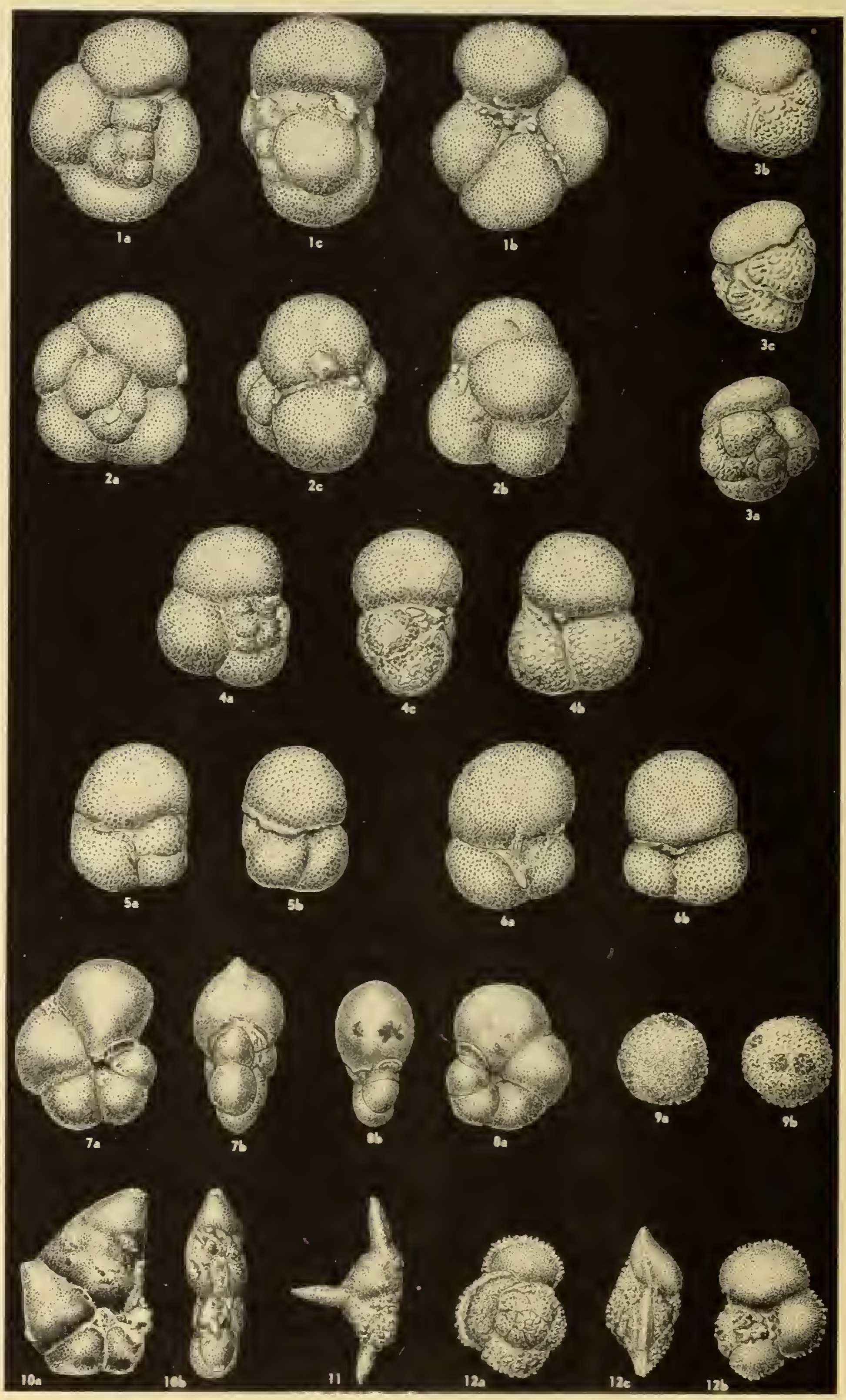
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PLATE 22

GLOBIGERINIDAE, HANTKENINIDAE, GLOBORATALIDAE

1. *Globigerina ouachitaensis* Howe and Wallace ×53. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228. Hypotype 43847.

2. *Globigerina ouachitaensis* Howe and Wallace ×53. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228. Hypotype 43848.

3. *Globigerina decepta* Martin ×53. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228.

4. *Globigerina triloculinoides* Plummer × 53. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228. Hypotype 43849.

5. *Globigerina triloculinoides* Plummer ×53. *a,* dorsal view; *b,* peripheral view. U.C. Loc. B-2233. Hypotype 43850.

6. *Globigerina triloculinoides* Plummer × 53. *a,* dorsal view; *b,* ventral view. U.C. Loc. B-2234. Hypotype 43851.

7. *Globigerinella micra* (Cole) ×62. *a,* side view; *b,* apertural view. U.C. Loc. B-2235. Hypotype 43852.

8. *Globigerinella micra* (Cole) × 62. *a,* side view; *b,* apertural view. U.C. Loc. B-2235. Hypotype 43853.

9. *Orbulina universa* d'Orbigny ×62. *a, b,* opposite sides. U.C. Loc. B-2251.

10. *Hantkenina dumblei* Weinzierl and Applin × 53. *a,* side view; *b,* peripheral view. U.C. Loc. B-2234.

11. *Hantkenina alabamensis* Cushman × 53. U.C. Loc. B-2228.

12. *Globorotalia crassata* (Cushman) var. *aequa* Cushman and Renz ×53. *a,* dorsal view; *b,* ventral view; *c,* peripheral view. U.C. Loc. B-2228. Hypotype 43855.

PLATE 23

ANOMALINIDAE

1. *Planulina haydoni* Cushman and Schenck × 51. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2252. Hypotype 43923.

2. *Planulina haydoni* Cushman and Schenck × 51. U.C. Loc. B-2252. Hypotype 43925.

3. *Planulina haydoni* Cushman and Schenck × 51. U.C. Loc. B-2252. Hypotype 43924.

4. *Anomalinoides* cf. *A. globosa Brotzen* × 61. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2228.

5. *Anomalina garzaensis* Cushman and Siegfus × 61. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2228.

6. *Anomalina californiensis* Cushman and Hobson × 61. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2263. Hypotype 43736.

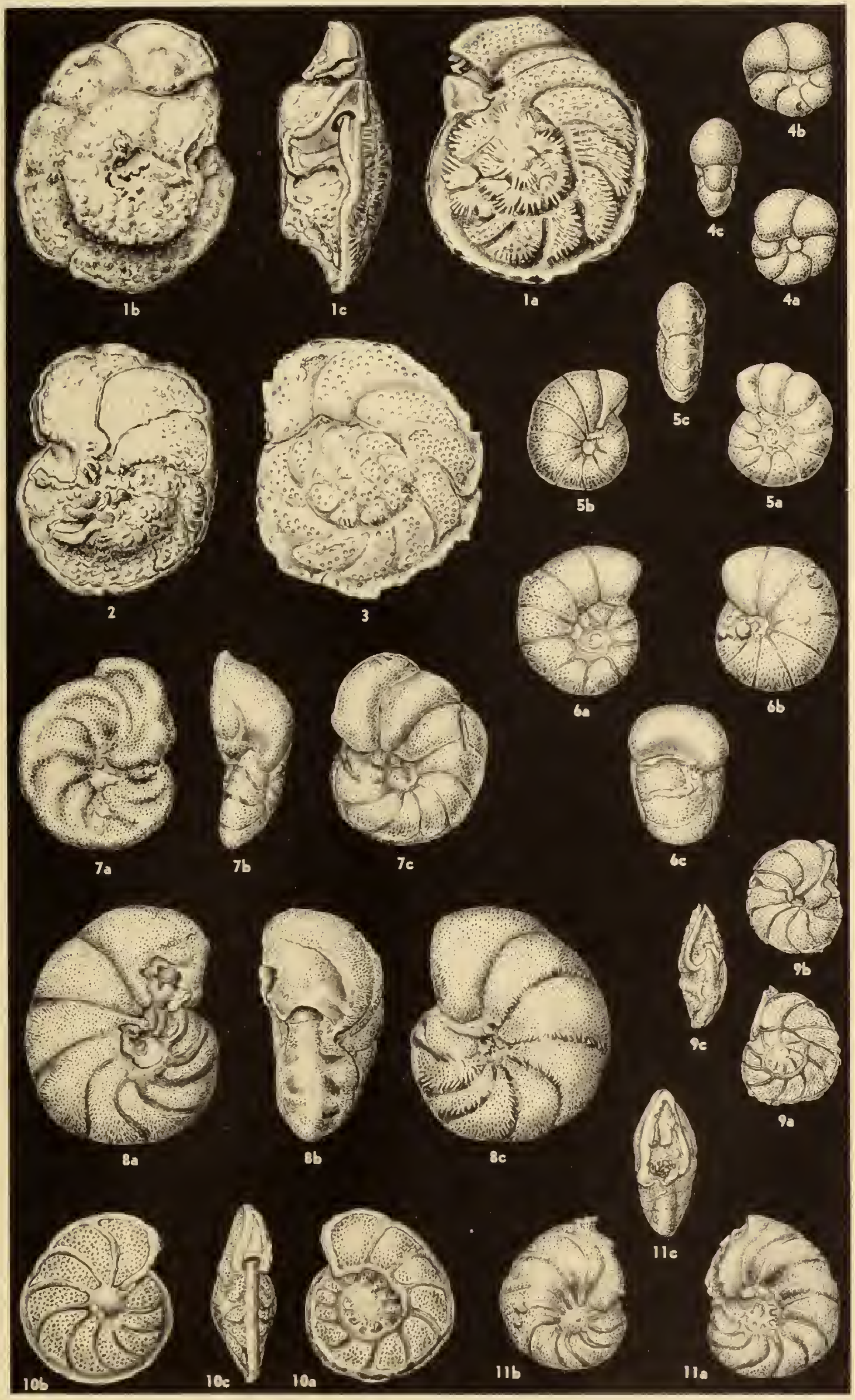
7. *Cibicides cushmani* Nuttall × 51. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2228.

8. *Cibicides hodgei* Cushman and Schenck × 51. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2252. Hypotype 43779.

9. *Cibicides falconensis* Renz × 51. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2233.

10. *Cibicides pseudoungerianus* (Cushman) var. *evolutus* Cushman and Hobson × 51. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2262. Hypotype 43781.

11. *Cibicidoides* cf. *C. midwayensis* (Plummer) × 51. *a*, dorsal view; *b*, ventral view; *c*, peripheral view. U.C. Loc. B-2270.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